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The 24-hour sprint race

How transmission tech developments solved the durability problem at Le Mans

The 24 Hours of Le Mans has been a regular fixture on the motorsport calendar for a century now. The circuit, and car technology, have improved beyond recognition in that time. Reliability is also better than it ever was, so how hard can it be to win the race?

Obviously, a quick car is a given if you are to succeed at Le Mans, with aerodynamic efficiency a major factor given the high average speed. A crack team to run the car to the very specific prescriptions of the ACO regulations is also a requirement, along with a highly focused squad of top drivers. However, the most important part is the vehicle and team durability to run at a high level for 24 hours without making a mistake.

Durability testing

During the 1980s, Group C sportscar racing was dominated by Porsche. A host of works and private cars gave the German manufacturer a wealth of durability testing and information, which allowed its cars to win six consecutive Le Mans editions.

Jaguar beat Porsche in 1988, by just a couple of minutes, and only on its third attempt. By that stage, the race had become a 24-hour sprint. No longer were competitors allowed the luxury of nursing their cars for the final few hours.

Jaguar started the durability testing of its cars in 1986, running them at circuits like Estoril in Portugal and Paul Ricard in France, but only in daylight hours, and never the continuous testing that a 24-hour race demands.

While the circuit is of a very different character, it is no coincidence that Jaguar had won the Daytona 24 Hours earlier in '88 and had learned a great deal from the experience.

History records that during the 20th century, transmission-related issues made up over 60 per cent of the retirements at Le Mans and, sure enough, the gearbox proved to be the Jaguar's Achilles heel, too. The circuit is partially public road, which makes it impossible to test on, apart from a few hours alongside the rest of the field. Nowhere else exists that represents the continual high-speed running of Le Mans.

Toyota's TS010 Group C prototypes of the early '90s were similarly blighted by gearbox issues, with a best position of second in 1992.

The Japanese manufacturer took the problems seriously and flew the head of manual transmissions worldwide in to assess the issues. At the time, we (Jaguar) had John Barnard putting together a prospective F1 programme at our Norfolk base and felt it may be useful to also have his input. A clash of cultures ensued, with Barnard extremely critical of the Toyota gearbox in front of the very high-ranking Toyota chief. I remember this well, as I had to return the seething Japanese engineer to his hotel in Norwich that evening. To add insult to injury, the hotel was on Barnard Road!

All this was to change at around the turn of the century with two important developments.

First, the gradual introduction of paddle-shift transmissions, replacing driver operation of gear changing with electronics that controlled the power cut, timing and throttle of the shifts. It marked a step change in gearbox durability.



Audi's transmission dyno was a key element in Bentley's journey to victory in 2003

Second, while engines had long run on dynos to test power and durability, it was not until the late '90s that a powertrain dyno was built (by Audi Sport at Neckarsulm) that allowed the engine and transmission to be tested as one unit and drive the wheel outputs to simulate a lap of the Le Mans circuit.

The dyno could be run with a throttle trace of a pole position lap of the circuit, simulating the loadings the rear tyres would feel, even over kerbs. It allowed the shift system to be fine tuned so wear on the dog rings became almost invisible.

Despite this facility being purpose-built with an isolating system on the floor where the dyno was, the violence and energy of the gearshifts could be heard and felt throughout the building.

In early 2001, Bentley, using an engine built by Audi Sport, turned up with a purpose-designed Xtrac transmission and ran a successful 30-hour test with pauses only for fine shift tuning and wear observation. This facility was a key factor in the success of the Bentley project.

With the revamped Paul Ricard circuit coming on stream in 2002, it became the default venue for long distance sportscar testing. However, whilst the Vmax is similar to Le Mans, the average speed is lower. The track surfaces are also very different, and therefore the tyre compounds too, but the facilities are excellent. We must have done six 36-hour tests there during the Bentley Le Mans programme.

Open concerns

Due to the short time between final design and build, it was necessary for the car to run at the 12 Hours of Sebring in March. With that race being followed the next day by a 12-hour, one car test, we left Florida with a list of over 100 concerns to study in three months.

Prioritising those concerns only on the basis of driveability and durability made it simple to freeze the design of the Le Mans spec car, with two 36-hour tests still to run in April and May.

We used a test car for the final test with all the drivers and both car crews that would be running at Le Mans. This allowed the running procedures and car crews to gel, and diffuse any potential tension between the German and British elements within the team.

In the race itself, the winning car finished two laps ahead of its second placed team mate. The pit stop details show that the winner spent 12 minutes less in the pit lane than the no.8 car due to two non-service stops to replace batteries.

Despite the great and famous result, both cars were carrying a rear suspension problem during the race, which only came to light as the cars ran through a depression on the track at Vmax with full aero loading. The smooth Paul Ricard circuit, and even the fearsome bumpy concrete blocks at Sebring, had failed to flag this issue up.

There were very few mechanical items for the 2003 car which did not carry over from the previous two years, with the notable exception of the torsion bar rear suspension. 

History records that during the 20th century, transmission-related issues made up over 60 per cent of the retirements at Le Mans

Sauber's C44 weighs in under the 798kg minimum, and carries ballast that is attached to the survival cell, although Key is not willing to disclose how much



Building blocks

Sauber F1 technical director, James Key, explains how the Swiss team aims to lay a solid foundation for Audi's arrival in 2026

By DANIEL LLOYD



James Key joined last September, reporting to Sauber CEO, Andreas Seidl, who will also be Audi's F1 team boss



After five seasons racing exclusively under the Alfa Romeo banner, the famous Sauber name returned to the Formula 1 grid this year with a bright new colour scheme under the Stake F1 Team Kick Sauber moniker.

This exercise is set to last two seasons as Sauber bridges the gap between Alfa Romeo's involvement and Audi's full takeover of the Swiss team for a factory effort in 2026.

However, Sauber doesn't want to simply tread water during the transition. The team adjusted its car design philosophy last year and is determined to make that work as it seeks to rise through the midfield. It also has a chance to set the table ahead of Audi's highly anticipated entry into the series.

Considering the level of investment and development required to get its F1 programme going, Audi will at least want to have a solid set of results on which to build.

Sauber's stint under Alfa Romeo branding had flashes of success, but ended with an underwhelming 16 points and ninth place in last year's 10-team World Constructors' Championship. That was an especially disappointing result after a strong preceding season in which the team put 55 points on the board, finishing sixth overall.

The end of Alfa Romeo's involvement coincided with Sauber taking a new direction for its 2024 challenger, the C44, which continues to use a Ferrari customer powertrain. The team hopes that this year lays the foundations for a strong ending to the 2022-2025 rules cycle, in turn giving Audi as good a starting point as it can. This means there are many strands of development going on at Sauber's base in Hinwil, Switzerland.

Parallel paths

'We've got three things in parallel right now,' says Sauber F1 technical director, James Key, who joined the team last September. 'We've got the here and now – our pit stops and developments to move us up the grid.

'Of course, there is 2026, too. We've got a little bit of concept work going on the chassis side there, although it's reasonably small scale in the team.

'And then you've got the project side, building the team up to where it needs to be to match the expectations of an Audi F1 team in the future. That's an enormous project, and we're right in the throes of that now.'

Key returned to Sauber having previously been its F1 technical chief in 2010-'12 before moving to Toro Rosso (currently RB) and then McLaren. His predecessor at Sauber, Jan Monchaux, now holds the post of the FIA's single seater technical director.

Key looks back on the team's challenging 2023 season as a 'voyage of discovery'. Despite starting his current job in the second half of that campaign, the Brit was dialled into



Key slotted right back into Sauber, finding himself 'finishing off conversations from 12 years ago' with long-time members of the team



The Alfa Romeo C43 struggled in high-speed cornering and wet weather. Changes for C44 are aimed at addressing these shortcomings

the shortcomings of the Alfa Romeo C43 and what changes needed to be made.

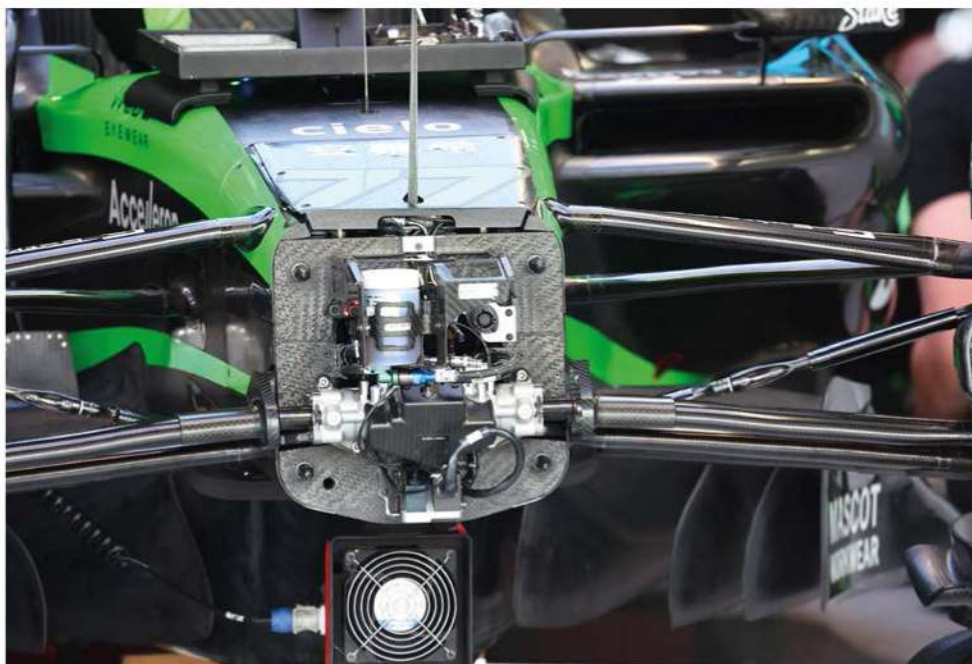
'I think the beginning of the season seemed to be a period of reflection. Is our philosophy correct here? The conclusion was, probably not,' Key summarises.

'There was a trend developing and we weren't on that trend. We needed to figure out what to do. That happened in the first half of the season. When I joined, there was a fairly steep trajectory towards a new direction – in my view, the right direction – for the car. And towards the end of the year, a lot of updates came out of that.

'Aerodynamically, it became a lot more prolific. Mechanics and aerodynamics are very closely linked, so then there was a lot of mechanical work to catch up with the aerodynamic directions being taken.'

The C43 was lacking in multiple areas, such as high-speed performance, wet weather pace and race day speed, relative to qualifying. The C43 reached the third and final stage of qualifying seven times, with drivers, Valtteri Bottas and Zhou Guanyu, both making the cut in Hungary and Mexico, but ultimately none of those chances were converted into points.

'We felt we should have been able to score points with at least one car, but we just went nowhere on Sunday,' admits Key. 'That was obviously a big topic of discussion. We were missing some fundamental tools on how to extract the most out of the car over the course of a race weekend, particularly with the challenges of running the car low. It was definitely a period of learning and transition when I came in.'



The additional mass that came from changing to pull rod front suspension has been offset by weight saving measures elsewhere



Re-designed radiator inlet and aggressive undercut beneath the sidepod increases the volume of airflow through to the back of the C44

Running cars low without the compromise of underfloor wear is key to getting the most out of today's F1 rule set, which places heavy focus on ground effect downforce generation.

The 'transition' that Key mentions refers to Sauber's gradual movement in the direction of a new car design through its upgrades last season.

New direction

'What we've done for C44 is consolidate where we want to be, and then design the car specifically around the philosophy we wanted to pursue,' Key adds. 'So, rather than having the hybrid situation we ended up with last year, we've got a car which is based on, and run around, a philosophy that it was converted to last year, but with a car that's designed for it.'

Sauber revealed the C44 in London on 5 February. The first noticeable difference from the previous year's car was a nuclear green and black livery, which helped emphasise the team's independence between its Alfa Romeo and Audi chapters. Technical changes soon became apparent too, as the car completed its first miles on a filming day at Barcelona before linking up with the F1 field at pre-season testing in Bahrain.

The C44 sports a more aggressive undercut below each sidepod, echoing the direction many teams have taken after Red Bull's successful application of the idea. This creates more volume for air to flow through towards the back of the car.

Above the sidepod, the radiator cooling inlet has been re-designed with a pronounced underbite. Despite these items

What we've done for C44 is consolidate where we want to be, and then design the car specifically around the philosophy we wanted to pursue'

James Key, technical director at Sauber

having clear similarities to the ruthless Red Bull RB19 that dominated last year, Key was quick to point out at pre-season testing that it was an 'in-house effort and philosophy' from Sauber, although he also acknowledged that design convergence between the midfield teams had occurred.

Sauber evolved the C44 to have an A-frame roll hoop, which has become the style of choice. Its previous F1 car had a distinctive double-layered hoop, but it has now moved to the more common design after the FIA increased static load test requirements in response to Zhou's massive crash at Silverstone in 2022. On the C44, this required some re-organising of cooling pathways to the powertrain, but the team says the aerodynamic impacts of the A-frame hoop have been minimal.

'During testing we found there is a significantly larger range of mechanical options and ways you can set up the car, compared to last year's car,' says Key. 'Because there was a wide array of options there, we experimented quite a bit.'

Sweet spot

'From Jeddah onwards, we've begun to find the sweet spot of the car mechanically,' he adds. 'In some cases, that's required some new, or additional, approaches to be taken. It's led to a lot of experimenting on that side.'

'We've got a few mechanical updates we're looking at that may complement that down the line. We've been doing a lot of work on grounding resistance.'

Much of the C44 design concept had been finalised before Key joined, including the decision to switch to a pull rod front suspension. Coincidentally, Key was McLaren's technical director in the first season of ground effect rules in 2022, when the British team rolled out with that type of suspension layout.

McLaren and Red Bull were the only teams to run a pull rod system on the front until Sauber and RB joined them this year. Ferrari, and its other customer, Haas, have remained with a combination of pushrods on the front and pull rods on the rear. The C44's rear suspension remains push rod.

Sauber's switch to pull rod front suspension was driven by aerodynamics.

Generally, this arrangement is more of a handful than pushrod. For example, the pull rod starts at the bottom of the chassis, making it harder for mechanics to access than a pushrod, which starts at the top. A pull rod configuration is also heavier because it requires weight to be added for increased stiffness and structural integrity, mainly within the chassis. Sauber's decision to fit the C44 with a pull rod was taken last spring.

'It's a heavier, more compromised solution, [but] I have to say, it hasn't been an issue,' Key reports. 'It's done what it's supposed to do. Front vertical stiffness, which is typically the parameter which pull rod vs pushrod is most affected, hasn't been one of those difficult challenges. It's more been about the overall heave rates, ride height trajectories and mechanical balance that you've got to try and get right.

'Loads are slightly different compared to a pushrod, so you've got structural mass increases around all those components. The pull rod itself, and its connections, will have a compliance level that is higher. You just have to make sure they're okay.'

Upgrade timeline

Sauber brought its first C44 upgrade, a new front wing, to the third round in Australia. It featured new third and fourth elements and a re-designed end plate, and was designed to improve the car's aerodynamic efficiency.

It was swiftly followed by a bigger update for the Japanese GP, where the C44 arrived sporting a new floor body and edges in the front and middle sections. They formed part of an effort from technical management to be early out of the gate with upgrades.

'We've pushed very hard, mostly on the aero side, but mechanically, too,' says Key.



The original front wing that Sauber brought to the opening two races in Bahrain and Saudi Arabia wasn't used for long

'A lot of mechanical projects have gone into the early season. The team have responded really well to that in every respect. Although it's not obvious from results, which has been down to issues on a Sunday more than anything, we have introduced a new front wing and two new floor specs already this season, which I don't think any other team has done. All of them have been for performance.'

From the early-season performances, Key reckons this year's car is better in race trim than the C43 was.

'Bahrain didn't quite work out for us on Friday,' he says, 'but on Saturday we stuck Zhou just outside the points and he stayed there. It showed us that our race performance had taken quite a significant step to last year.'

Making that performance shine through, though, has been the biggest challenge.

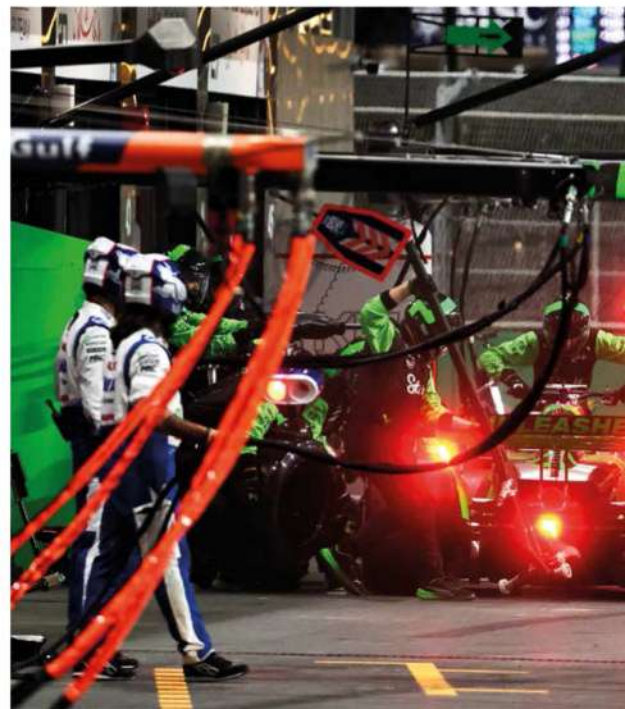
Gunning for glory

On lap 30 of this year's season-opening Bahrain GP, Bottas came in for his second pit stop, only for disaster to strike when there was a huge delay on the left front wheel change. A wheel nut had become cross-threaded, preventing the mechanic from attaching the new wheel. The delay cost Bottas around 50 seconds and the Finnish driver ended up 19th.

The following weekend, during the Saudi Arabian GP in Jeddah, the same thing happened, this time on the right front of Zhou's car. Alarm bells started ringing. Clearly, the Bahrain incident hadn't been a one-off.



Sauber introduced several new parts to speed up its pit stops, but that ended up having quite the opposite effect





Sauber introduced a new front wing in Australia, making an early start on its upgrade schedule, but then came the wheel nut episode(s)

Sauber then re-grouped for the Australian GP a fortnight later, only for another Bottas stop to go awry. This time a wheel nut pinged out into the pit lane, drawing a €5000 (£4280) fine. Although this wasn't the same problem as the previous two incidents, it was enough to attract further probing headlines.

Sauber upgraded its tyre change equipment over the winter to improve its pit stop times. This included new wheel guns with a different switching mechanism to reverse the direction of the socket. The nut is held loosely in place within the wheel by a collar-like retainer and then high torque from the wheel gun forces the nut to turn into a tight position, securing the wheel in place.

'Our stops were a bit slower than they should have been, and we knew there were

some compromises with the shape of the axle compared to many other teams who had taken the next step,' reflects Key. 'We did a retainer system that works slightly differently. That just needed a new design of wheel nut and axle, but all with the same materials to last year.'

Sauber tested its new arrangement at Hinwil over the winter and, according to Key, the team was satisfied, despite still suffering occasional cross-threading episodes. These incidents, he acknowledges, were the sort of thing that could happen to a team that still uses aluminium wheel nuts.

'From Imola to Barcelona, we're going to see some much bigger changes on the axles for our car,' projects Key. 'They are long lead time bits that require a lot of design and R&D

'Although it's been a very public thing, the hope is we're on top of the two primary issues we had at the first two races'

James Key

work to get right, so we couldn't hit the beginning of the season with them. It rang a few alarm bells, but it wasn't an issue that was on everyone's mind.

'And then on Sundays, we'd suddenly have these issues. They really caught us out. It was a big surprise.'

More importantly, the cause of the cross-threading was not immediately clear.

Head scratcher

'We did a huge amount of R&D trying to recreate exactly the catastrophic failures, but we couldn't do it, however difficult we made getting the wheel on,' says Key. 'We would hold the wheel off in a really difficult angled position and then gun an aluminium nut on really quickly, hitting the threads together. Whatever we did, we couldn't recreate the problem we experienced in the race.'

It's unclear why Sauber has not been able to replicate the issue. This undoubtedly made it harder for the team to wrap its head around what solution was required. At time of writing, Sauber is planning to introduce wheel nuts made of a more robust material in time for the Emilia-Romagna GP at Imola.

'Although it's been a very public thing, the hope is we're on top of the two primary issues we had at the first two races,' says Key.



Cross-threaded wheel nuts prompted a quick response, and new materials are being introduced at a 12-week lead time



No wheel nut issues occurred in round four at Suzuka, but Bottas lost track positions at a pit stop when challenging for points



With a new car, a new technical director and Audi's influence starting to be felt in the background, Sauber looks well placed to be one of the key players in a tight midfield battle this year

'At Imola, we're going to see a lot of new bits in that area, which we can rush through as quickly as possible. These are 12-week lead time parts, typically, so that was an excellent effort from our suppliers and production guys.'

The slow stop for Bottas in Australia was not caused by a cross-threaded wheel nut, after Sauber made some changes to rectify its earlier issues. A wheel peg became lodged between two pockets in the wheel hub. This meant that when the gun trigger was pulled, the wheel nut spun violently and popped out.

'For Melbourne, we changed certain details of the thread to make it easier for the nut to go on,' explains Key. 'We did a lot of video analysis and recognised that the cross-threading was happening due to another issue occurring in the wheel-on condition. We began to put a picture together of what was different in R&D, but it was still robust so that was frustrating. What happened in Melbourne was another issue, just extremely bad luck.'

Audi influence

The short-term focus on pit issues and the C44's development are small, yet not unimportant, tesserae in the wider image of Audi's entrance. In March, it was announced that the German automotive giant would be purchasing a 100 per cent stake in the team, more than previously anticipated.

It has installed technical development officer, Oliver Hoffmann, as the head of its single seater commitment and Andreas Seidl as Audi F1 Team CEO. Those working

in technical at Hinwil are already feeling the influence of Audi's gestating masterplan, which includes work on its Neuberg nerve centre where the powertrain is being developed.

'The investment and seriousness you can see in this project is immensely impressive,' comments Key. 'There's a reason you get the same teams – Red Bull, Mercedes, Ferrari – in the top three. They've done that investment already, without the cost cap, and over many years. We've got a lot of catching up to do.'

It is not the first time Sauber has been part of a works F1 entry. A four-year spell with BMW ended when the German car giant withdrew after 2009, leaving Sauber as an independent squad following a buy-back from its founder, Peter Sauber.

The company was then sold in 2016 to Longbow Finance, owned by Swedish billionaire, Finn Rausing, whose continued investment was spurred by Alfa Romeo's title sponsorship. The BMW programme brought investment to Hinwil, but further input from Audi will be a much-needed boost to Hinwil.

'We're very aware of what our deficits are, and we're still miles away on the R&D side, but we've got a huge opportunity'

James Key

Currently, the Sauber technical team consists of around 240 people (in a total workforce of about 600) and that number is increasing. Key says there are 'huge opportunities' for Sauber to grow under Audi's leadership, but it remains to be seen if the team is in the early stages of an upward trajectory that may see it return to the race-winning level it reached in the BMW years.

'We've got technologies we need to bring in that bigger teams than us have been using for a long time,' says Key. 'We've got processes we need to revise and improve upon. We've got manufacturing capabilities which are good, but we're a small team. If we can make them better, not only is it cost cap savvy, but you can push developments through quicker. Or you can leave your definition dates later.'

'The new software tools generated internally are excellent, but there are still lots of tools that need updating. We're very aware of what our deficits are, and we're still miles away on the R&D side, but we've got a huge opportunity and that investment and support is going to allow us to make, over the years, some big steps towards the goals we've got.'

Sauber clearly has ambitions to win races under the Audi F1 Team. By the time the programme starts, it will be 18 years since Sauber's last victory. Getting to that point will not only require Audi's full backing, the Swiss arm of the operation also has its side of the bargain to uphold, so the present task of challenging for midfield points with the C44 is just as important as the bigger picture. **R**



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Blood Type R

Honda has taken the bold step to radically change its GT500 contender for 2024 and acknowledges that, in doing so, it has given itself a mountain to climb

By JAMIE KLEIN



This is the first time any manufacturer has opted to use a front-wheel drive, five-door hatchback as the basis for its GT500 challenger



Believe it or not, Super GT heavily limits the amount of aerodynamic development that can be done, so choosing the right base car is crucial to success in the series

After a decade of racing GT500 cars based upon the second-generation NSX, Honda has elected to make a major shift for the 2024 season by introducing the all-new Civic Type R-GT in a bid to win the top class Super GT title for the first time since 2020.

It marks the first time any manufacturer has opted to use a front-wheel drive, five-door hatchback as the basis for its GT500 challenger, and certainly marks a major departure from the NSX-GT that had become such an icon of the series. Although the NSX is no longer sold, no doubt there are many fans who would have been happy to see Honda keep the midship supercar as its weapon of choice for many years to come, much as it did with the first-generation NSX, even after that car went out of production.

This time, not long after the second-generation NSX ceased assembly following a limited run of 'Type S' models in 2022, Honda

gave the world its first glimpse of the Civic Type R-GT in concept form at the annual Tokyo Auto Salon exhibition in January 2023.

That was followed by the reveal of the car in something close to its final version in late July, at Okayama International Circuit, where it was also given its first track test.

Performance ceiling

The reasoning Honda gave for the radical change was twofold. With no 'halo' model to replace the NSX in its road car range, it made sense for it to promote the Type R brand as the centrepiece of its performance offering, a throwback to when the Civic was used in touring car racing in the 1980s and 1990s. At the same time, Honda felt it had hit a performance ceiling that would be hard to overcome without a change in base model.

'Honda had been using the NSX-GT continuously from 2014 until last year, so developing a different car like the Civic Type

R-GT offers us the chance to do something different, especially in terms of starting the development of the aerodynamics again from scratch,' says Tomohiro Onishi, Honda's Super GT chassis design and development leader.

'According to the regulations, the area of the car where we can develop the aerodynamics is very limited, and which base car you use has a big impact on this. The shape of the base car has a big effect on the car's performance characteristics, and so, compared to the NSX, there are some advantages and disadvantages with the Civic. It's our job to make the most of the good points and limit the effects of the negative ones.'

In common with its GT500 rivals from Toyota and Nissan, the new Civic Type R-GT is based on the same Toray Carbon Magic-produced chassis as the old NSX-GT, which forms the basis of the Class 1 rule set that lives on in Super GT, despite having been abandoned in the DTM three years ago.



‘Compared to the NSX, there are some advantages and disadvantages with the Civic. It’s our job to make the most of the good points and limit the effects of the negative ones’

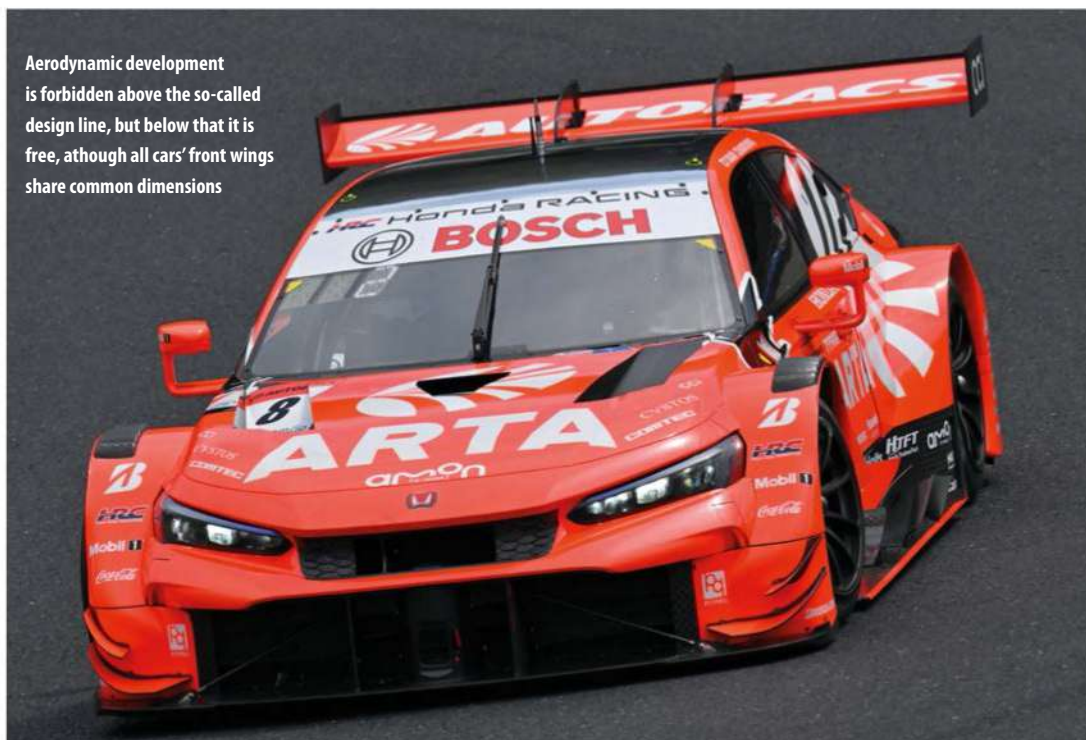
Tomohiro Onishi – Super GT chassis design and development lead at Honda



Cars are powered by four cylinder, turbocharged engines based on the roadgoing variants, but drive through a spec six-speed Hewland gearbox mounted longitudinally and are now rear-wheel drive



The new Civic Type R-GT is based on the same chassis as the NSX it replaces, which is common across manufacturers and forms the basis of the series' Class 1 rule set



Aerodynamic development is forbidden above the so-called design line, but below that it is free, although all cars' front wings share common dimensions



The Civic body had to be stretched to fit the spec chassis, and squashed to fall in line with GT500's 'scaling' rules

While the roadgoing Civic is front-wheel drive, the GT500 version utilises an FR (front engine, rear-wheel drive) layout in accordance with Class 1 rules, with the four-cylinder, turbocharged engine linked to a standard six-speed Hewland gearbox. The Bosch ECU is also standard, as are components such as the underfloor, rear wing, brakes and dampers.

Being narrower and shorter than the NSX base model, the Civic has had to be stretched to fit the footprint of the common chassis, while being squashed down in terms of height in accordance with the GT500 'scaling' rules. However, while the regulations are aimed at enabling all base models to compete with one another on a level playing field, some turned out to be more equal than others. Specifically, Toyota and Nissan both found success by moving from larger GT-style designs, the Lexus LC and the GT-R respectively, to more sports car-type body shapes in the form of the GR Supra (in 2020) and the Z (in 2022).

Design line

In the GT500 regulations, the area open for aerodynamic development is governed by the so-called 'design line'. Above the line, the car must follow the styling of its roadgoing counterpart, but below it, anything goes.

Adopting a base model with a narrower front fascia allowed both Toyota and Nissan to maximise the flat area above the wheel arches in order to improve aerodynamic performance, and it's clear Honda is pursuing a similar philosophy with the Civic.

'The problem with the old NSX was scaling the width of the car,' explains Onishi. 'With a supercar-style car like the NSX, which has a small cabin and wide body, the width of the cabin has to be matched to the other [competitors], but because the bottom of the car was very wide, the area free for aerodynamic development was taken up by the base car, which was a problem.'

'The Civic, on the other hand, is a more normal car. The width of the cabin and the front of the car are about the same, and making it into a racing car, you can tell it is narrower at the front.'

'The front fenders [wings] have common dimensions for everyone but, with the NSX, there was an overlap with the shape of the base car. With the new Civic, you can see a lot more of the front fenders. In that respect, the appearance has become more similar to the [Toyota] Supra and [Nissan] Z. That is one of the advantages we have obtained by changing to the Civic.'

'The Civic generates much less drag, but also less downforce [than the NSX]. Our efforts in development have therefore been focused on raising the level of downforce'

Tomohiro Onishi

Last season, the NSX-GT was widely considered to be at the high downforce end of the spectrum, compared to the GR Supra and the Z, although this didn't necessarily translate into the performance advantage you would have expected at tracks such as Suzuka and Autopolis, with their many medium-to-high speed corners.

The Civic, however, appears to sit firmly at the lower end of the scale, at least on the evidence of the winter testing times, when cooler temperatures and denser air give higher downforce machines more of a boost.

Life's a drag

Onishi is reluctant to speculate exactly where the Civic fits in against its GT500 rivals, which have undergone modifications of their own over the winter amid the lifting of Super GT's aerodynamic freeze. But he is happy to compare the new car to its predecessor.

'One of the factors with the previous NSX was that the base shape generated a lot of drag, as well as downforce,' he says. 'The Civic generates much less drag, but also less downforce. Our efforts in terms of development have therefore been focused on raising the level of downforce, but we don't think we will get back to a level of drag similar to the NSX.'

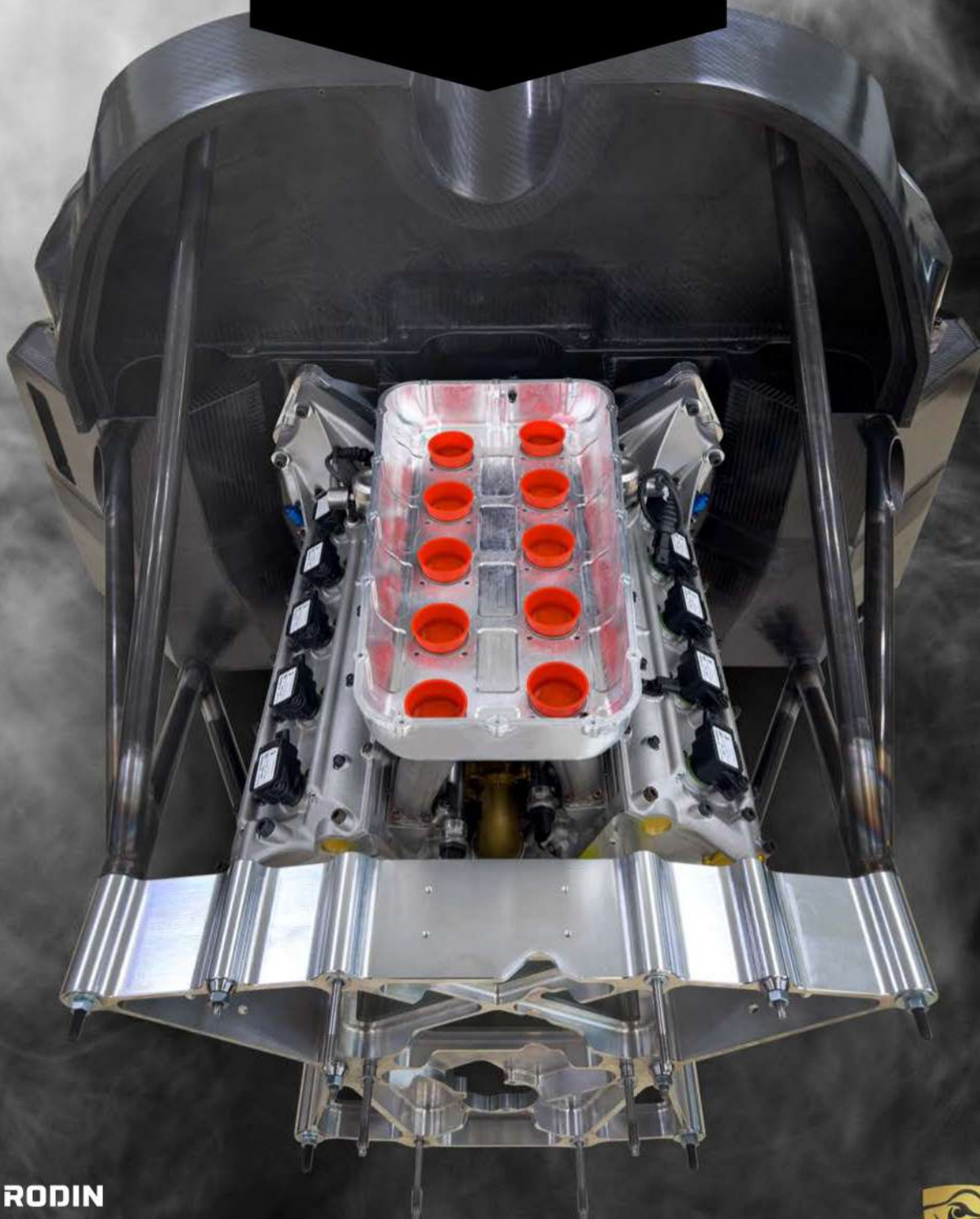
'By the same token, we also won't be able to extract as much downforce as before.'

'We are trying to develop the car in such a way to take advantage of the characteristics of the Civic, and so we are moving away from the old downforce-first philosophy.'



Moving to a more regular production car shape changed Honda's aerodynamic philosophy, and subtle tweaks are still being made to optimise the design before the next aero development freeze

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While wet weather in many of the off-season tests has blurred the picture somewhat, Onishi is certain that the Civic Type R-GT is quicker in a straight line than its predecessor. However, a look at the speed traps when it has been dry suggests Nissan remains out in front in this regard, with the Z having topped 300km/h along Fuji Speedway's almost mile-long straight at various points in the last two years.

'I don't think we can reach that level,' is Onishi's honest assessment.

All-round speed

From an aero point of view, though, Honda is hoping to emulate the trend seen with the Z, which is its ability to be quick at just about any circuit.

'The characteristics of the NSX made it easy to predict where we could perform well,' continues Onishi, 'but we think with the Civic, this kind of variation won't be there any more and we will be able to perform more consistently across all circuits. Now we have a car that no longer has especially good tracks and bad tracks.'

Since the car's initial rollout at Okayama last July, the Civic's aero package has undergone some visible tweaks. As of the final pre-season test at Fuji in late March, Honda appeared to have settled on a two-canard design in the 'flick box' area, having experimented with a three-canard design at other circuits. The 'elephant foot' area has

also undergone some subtle evolution, with the Fuji configuration retaining the same basic four-element design as seen on the car's launch, but with a much shallower final element at the rear.

With the aerodynamic development set to be largely frozen for both this season and next, the importance of finding the optimum solution cannot be overstated.

Aerodynamics are not the only area Honda has been working hard on over the winter, as there have also been tweaks to the layout of the engine. The manufacturer has retained the same turbocharged, inline, four-cylinder HR420E of previous years, not wanting to overcomplicate things with a major change in philosophy at the same time as changing the car, but the difference in body shape compared to the NSX has permitted a beneficial change to the layout and design of the engine cooling system.

Instead of having a radiator on each side of the engine bay with the intercooler in the

middle, the intercooler has been shifted to the right-hand side, with a single radiator on the left. The reduction from two radiators to one achieved a significant weight saving, and also a lower c of g.

While the cooling capacity was similarly reduced, Honda calculated that Super GT's move to carbon neutral fuel for the start of the 2023 season meant less cooling was required, as the engine had to be modified to deal with higher water temperatures.

Optimising this new system was the focus of Honda's early tests with the Civic, which were conducted with the no.99 development car at Motegi, Sugo and Fuji.

The first of the Honda race teams to put miles on their new cars were Team Kunimitsu and Nakajima Racing, both doing so at Sepang in January during Super GT's first international test since the pandemic. The two-car ARTA team and Real Racing got their programmes under way in early February at a private manufacturers' test at Okayama.

Race debut

Onishi wasn't expecting miracles for the car's first race, given that in testing at Sepang, the deficit between the leading GR Supra and the best Honda was 0.762 seconds.

The Civics were down on pace at three subsequent tests, although the gap was reduced to just over half a second at two of them. Nonetheless, the race debut at Okayama saw Team Kunimitsu finish third.

The difference in body shape compared to the NSX has permitted a beneficial change to the layout and design of the engine cooling system



Winter testing failed to show the full potential of the Civic Type R-GT, but Honda is confident the car is quicker than the old NSX in a straight line, though still a way off the speed of Nissan's rapid Z



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Fuji appeared to be the Civic's strongest test venue, as ARTA man, Nobuharu Matsushita, topped the timesheets in the final session of pre-season, but with the caveat of the track being green following rain showers.

The other factor to consider is that four of Honda's five driver line ups are new, with only Team Kunimitsu's 2020 title-winning pair, Yamamoto and Tadasuke Makino, staying together over the winter. Ren Sato (ARTA car no.16) and Riki Okusa (Nakajima Racing) are GT500 rookies, while Kakunoshin Ohta (Real Racing) is new to Bridgestone tyres after making his debut last year for Nakajima on Dunlops. Add in the fact that two of the five Honda crews also have new track engineers and there are plenty of unknowns to consider.

'The five teams, and the driver and engineers... there are still a lot of things they have to learn about the final specification of the car, and so there may be some teams who are able to perform right away and others that take a little bit longer to get up to speed,' Onishi concedes. 'At the same time, we are aware that the other two manufacturers both have very strong packages, so trying to beat them this year will be a big challenge for us.'

Super GT manufacturers winning the GT500 title in their first year with a new base car isn't unheard of. Nissan did so when it replaced the GT-R with the Z in 2022, and two years earlier, Toyota came heartbreakingly close to a debut title with the GR Supra, only losing to Honda when the TOM'S machine driven by Ryo Hirakawa ran out of fuel at the final corner of the last lap of the season.

Hard results

That remains the last time Honda won a title in GT500, with the Sakura brand suffering a title-decider heartbreak of its own a year later when Yamamoto's Team Kunimitsu car was harpooned by Sato's ARTA GT300 machine while in a strong position to clinch the title.

Honda went into 2023 as the favourite off the back of its strong late 2022 form and some stunning pre-season testing times, including a new unofficial lap record at Suzuka. And yet, for a variety of reasons, not least the introduction of carbon neutral fuel, it didn't translate into hard results.

'In recent times, there have been seasons when we thought we had everything we needed to win the title and somehow we

were not able to win it,' says Onishi. 'Having this experience when we considered all our preparations to be perfect, it makes you realise just how difficult it is to win the championship in GT500.'

'Therefore, I can't say I am totally confident that this year will be the year we win the championship with the new car.'

Certainly, Nissan's instant success with the Z in 2022 puts a certain amount of pressure on Honda but, whereas the Z was rapid from an early stage in testing, the Civic has generally been third best, which shouldn't be a surprise considering just how seismic the change from the NSX has been. However, the deficit is small enough to suggest that Honda should pick up at least one victory with the help of Super GT's success ballast system, and the car also looked strong in the rain at Fuji.

Even if a title assault doesn't prove possible this year, Honda hopes to lay the foundations for future success as it learns how to get the most out of the radical new Civic. If it does reach the summit, no doubt its success will taste all the sweeter for having done so with a car, in true Honda fashion, that very much stands out from the crowd. **R**

Honda readily acknowledges it has a long way to go in the debut season with the new Civic R-GT, but the ingredients are all there, and the car achieved a podium on its first competitive outing at Okayama



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Engineering and data matters at BTCC rounds are directed from TOCA's technical truck, giving the series a clear picture of what's going on

National staple

We explore the present and future of the British Touring Car Championship as it heads into its third season with hybrid power

By DANIEL LLOYD

The British Touring Car Championship (BTCC) is now in its third season with hybrid powertrain technology. Each campaign of the TOCA-run series' electrified era has resembled a different stepping stone in the journey so far. Year one was about getting to grips with the 48V system, year two exposed some of the sporting shortcomings, and year three is now about making improvements.

The headline change for 2024 is an increase in boost from the hybrid powertrain, which consists of a Cosworth hybrid system, Xtrac gearbox, Owen Developments turbo and an engine of the competitor's choice.

Through upping the turbo, the amount of power available to each driver at the push of a button, for up to 15 seconds per lap, has doubled to around 60bhp. This is part of a drive to maintain the BTCC's reputation as one of the most competitive series in the world.

An exciting on-track product, combined with a free-to-air television package on ITV, has been the recipe for huge success in recent years. However, last season, TOCA management figures took note of areas in the hybrid deployment that could be improved.

The wild variations in performance that occurred under the old success ballast system had become less noticeable, resulting in fewer overtakes. As BTCC technical director, Sam Riches, admits, the on-track competition 'has not panned out as expected'.

Hybrid background

The low voltage, regenerative braking hybrid system was introduced as part of the BTCC's efforts to promote sustainability and road relevance. As a championship with manufacturer involvement from Ford, Toyota, Hyundai and BMW, it was an unsurprising move. It was also a pioneering

one, as the BTCC became the world's first hybridised touring car championship.

Aside from backing automotive industry trends, it was hoped that new strategic options and engineering challenges for the teams would arise.

Hybrids replaced the previous success ballast system used by the series so, rather than being laden with extra weight (up to 75kg, depending on the previous race result), successful drivers would instead have fewer laps to deploy hybrid power and higher minimum deployment speeds.

On a technical level, the hybrid system needed to produce a certain number of metres per second for a chasing car to pull alongside the vehicle in front. To complicate matters, that had to apply at all BTCC tracks, from a compact venue like Brands Hatch Indy, to somewhere like Silverstone, which boasts the long Wellington Straight.





The BTCC became the first touring car series to use hybrid power when the Cosworth system arrived in 2022. It has worked on matching the technology to its proven racing product since then

The on-track competition 'has not panned out as expected'

Sam Riches, BTCC technical director



Goodyear has introduced a new tyre construction with enhanced lateral stiffness - one leading engineer described it as a 'minor change' compared to last year



Teams had to adapt existing cars for the hybrid system. Work included beefing up front end components to protect the MGU and battery cooling systems on either side



Cosworth and Delta developed the 48V battery for BTCC. It has a 12V charging connection and a BMS that receives commands from the Cosworth Antares VCU

'In combination with the new tyre rules and the qualifying format changes, it's all about jeopardy and variability. Make it difficult for them to drive'

Sam Riches, BTCC technical director

'The hybrid did all that, and ticks all of those boxes to this day, but the theory didn't live up to reality in the racing,' reflects Riches. 'The only way to get more delta was to add, effectively, a traditional push-to-pass.'

'What drove it? Improving the racing. This championship is all about close racing, and that was its goal. Last year, they were doing a little bit here and there to get a better lap time. It's not what it was designed to do.'

Ultimately, TOCA wants its flagship championship to be a challenge for the drivers and engineers. This helps produce the exciting, battleground spectacle that brings thousands of fans through the gates at each round and makes for a strong TV product.

'We needed to add some more variability in, and that's what we've done with this [boost increase],' adds Riches. 'In combination with the new tyre rules and the qualifying format changes, it's all about jeopardy and variability. Make it difficult for them to drive.'

'These cars are not easy to drive or set up. One of the engineers coming back to the paddock this year has worked on LMDh cars and said there is more adjustability in one of these than there is in a prototype.'

Double the power

Although the big technical change for 2024 concerns the hybrid system, it is important to note that TOCA has not increased the amount of electrical power. Instead, gains are coming from the internal combustion engine side.



The increase in hybrid boost will not only help cars under acceleration - braking distances are expected to increase by up to 10 metres as a driver using the boost feature needs to slow down earlier. Closing speeds are set to increase, too

The hybrid boost – deployed when the driver pushes a button on their steering wheel – is now an approximate 50 / 50 split between electrical power and engine power. Previously, the electric motor did all the work.

'We've added a level of engine power to it,' explains Riches. 'Because we are limited to a nominal 48V system, in terms of health and safety, cost and various other reasons, you can't just magically generate more grunt with only 48V.'

'We've added an additional 200mb that works out at around 30bhp to double the amount available at the button. The operation is the same – they still press the button – but we're giving it more potency.'

The electric MGU is linked to the powertrain through a standard Xtrac six-speed sequential gearbox and is mounted in an off-axis configuration. A Cosworth Antares 8 vehicle control unit oversees the car's electronics, including the systems responsible for managing deployment and regeneration of electrical energy.

The hybrid system will deliver the initial kick in the first phase of acceleration, before the added turbo boost jumps in for an amplified push. As was the case in previous seasons, drivers can use the system to attack or defend. The planned difference for this year is an enlarged delta between a driver who's on the button and one who isn't.

'You've gone from just under a 10 per cent [overall power] increase on the button, to more like 16-18 per cent,' Riches confirms. 'One team has run it and, down the back straight at Snetterton, if they deployed it completely, they gained six tenths.'

Spending and saving

Usually, in motorsport, going faster means spending more money. The updates to the hybrid package have increased overheads for the teams, adding to what was already an expensive undertaking when the BTCC first went down its electrified route in 2022.

'The price of the hybrid lease has gone up,' says West Surrey Racing boss, Dick Bennetts.



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‘But that aside, the general feeling is engine life won’t be quite as good now, because you’re extracting an extra 30-odd horsepower out of the engine. But hopefully it makes the racing more exciting.’

TOCA has made some adjustments to address any reliability concerns. Two turbo boost steps, believed to be worth around 6-7bhp, have been taken away, but the 200mb increase has elevated it another 10 steps, for an eight-step net gain.

‘It gives a little bit of headroom,’ explains Riches. ‘Everything is a little bit lower and stress free to account for the increased stress of those 15 seconds. Cosworth has had to update the code, and engine builders have had to tune and map for the relevant strategies and target boost levels, but it’s nothing they wouldn’t normally do.’

It remains to be seen if the added boost will create as big a delta as success ballast did, although pre-season reactions were positive.

‘The biggest difference is the overlap,’ says Alliance Racing Ford engineer, Tony Carrozza. ‘Down the start-finish straight at Donington, there is a 16-metre delta. That’s four car lengths. If you come off the chicane on the bumper of the car in front, you’ve got enough deployment to get alongside, pull in front and have a car length in the braking zone.’

Bennetts is also positive about the update.

‘Last year it didn’t make a lot of difference at all, whereas now with the EV boost and engine boost, the driver can really feel it kick in,’ he says. ‘That can only be good for the future of the championship.’

Steadfast regulation

The current regulations platform to which all BTCC cars are built, NGTC (Next Generation Touring Car), has been around since 2011. Although it has not achieved the global prominence of TCR (Touring Car Racing), which has seen multiple manufacturers sell customer cars around the world, its staying power is testament to its strength.

The NGTC cars have become around 1.5 to two seconds quicker per lap over the last 14 years as the teams have unlocked more pace with the tools provided.

However, the BTCC organisers aren’t particularly bothered about whether NGTC has become faster, provided the racing is tight and it delivers a good show for the fans. Making the engineering challenge as great as possible for the teams, while keeping tabs of cost through single supplier contracts, is the underlying philosophy behind that.

Consequently, many parts of the NGTC car are spec, including the front and rear subframes from RML Group, which took over from GPRM as supplier in 2016. There is also a spec engine available, developed by M-Sport, which is used by teams that choose not to go down the route of developing their own.

Storm clouds may be brewing over grid size, so it's crucial that TOCA nails its future technical direction

‘The concept of NGTC has always been that there are spec components, but there is enough scope to [engineer],’ explains Riches. ‘The approach is: here’s your toolbox, you can do what you want within it. For example, on the damper there are two or three versions of piston, and a selection of shims available. As long as you use the shims that are listed, you can use as many or as little as you want.’

That gives teams scope to try out numerous different variations of parts and settings. An added variable is the continued mix of front and rear-wheel-drive machinery.

‘You still can do a reasonable amount because you’ve got different permutations within the RML kit: roll centres, geometries and so on,’ says Bennetts. ‘The regulations have been stable, but you can play with weight distribution within the chassis. Although you’ve got the minimum race weight to adhere to, which is 1325kg for FWD and 1355kg for RWD, which is something that needs reviewing.’

NGTC has also fostered great variety. A total of 16 car brands have been represented in the BTCC since the current rule set began. As a result, it would be easier to list the badges that have *not* appeared on the grid than those that have.

The series still regularly draws a competitive grid, although the current figure of about 20 cars is not as high as it used to be.

Only privateer teams running with Cupra and Vauxhall now make up the once thriving Independent Cup field outside of the four top category manufacturers. However, those that continue to believe in NGTC can still put their engineering competence to the test.

‘There are 499,200 combinations of front geometry and the cars are sensitive enough that the drivers can feel a 1mm change in inboard geometry,’ says Carrozza. ‘That doesn’t include spring rates, roll bar positions and stiffnesses, or camber. Every circuit we go to – depending on the conditions – we’re having to fine-tune those elements to where we need to be. It’s still very much an engineering exercise.’

‘The general feeling is engine life won’t be quite as good now, because you’re extracting an extra 30-odd horsepower out of the engine. But hopefully it makes the racing more exciting’

Dick Bennetts, team boss at West Surrey Racing

‘There is a lot of room for freedom, and that was always the point. We were never going to do a one-make formula where you turn up and can’t do anything’

Sam Riches



The hybrid system lease was originally priced at £20,500 (approx. \$24,900) per car per season, but that figure has risen since 2022. Nevertheless, BTCC technical director, Sam Riches, describes the championship's pricing as 'competitive' compared to elsewhere

This is the sort of endorsement that Riches and his colleagues will be happy to hear.

‘There is a lot of room for freedom, and that was always the point,’ Riches states. ‘We were never going to do a one-make formula where you turn up and can’t do anything.’

‘You can do what you want on the gearbox ratios and pre-load, as long as it’s using the bits on the parts list.’

Open playbook

NGTC is now well into its second decade, so what does the future hold? According to Riches, nothing is guaranteed after 2026.

And when he says nothing is guaranteed, he means that literally. It doesn’t just apply to the car platform either. Every exclusive technical contract, every business deal – including the ITV package – expires after the 2026 season.

‘It’s not intentional, it’s just lined up that way,’ he says. ‘We need to have set a direction in the next 12 months and start tenders to get people ready ahead of the game for what they need to do. What that looks like is very challenging at the moment.’

For a series that likes to communicate early (its calendar for the next season is usually released in May) it’s a little surprising a

clear direction for 2027 hasn’t yet been set. We’re only in 2024, but it can take years for major regulatory developments to be proposed, fleshed out and applied.

That could be a limited timeframe if TOCA does decide to do anything drastic with its powertrain technology.

The FIA World Rally Championship dropped a bombshell in February when it announced it would be abandoning hybrids next year, part way through its contract with spec supplier, Compact Dynamics. The BTCC is not looking to implement such a radical mid-rule set change, despite the ongoing cost burden for teams.

Like other suppliers to the series, Cosworth has a deal in place until 2026. Whether hybrids continue in the BTCC beyond that threshold is a more open-ended question. Riches and his team are conscious of automotive industry trends such as the slowing of electric car sales that has prompted some OEMs to alter their strategies.

‘Trying to make a decision for what the engine formula looks like in 2027 is a big challenge,’ Riches admits. ‘We don’t want to go full electric. ETCR proved how difficult that was. Whether there is an element of hybrid left depends on what is out there. What we have at the moment is not very relevant to where the automotive industry went to, but it serves a purpose.’

'We are actively testing R100, which is 100 per cent renewable fuel, with the hope of introducing that in the future'

Sam Riches

Is that serving a purpose for the racing or the commercial side? 'Both. In 2019, when we said we were doing hybrid, we had to have something on the roadmap about sustainability. We all agreed that hybrid was the way to do that. Whether we need to do that, whether we can [introduce] synthetic fuels at a later date... [we need to consider] whether that's suitable to maintain that push in the right direction looking after this planet. We have to do something but, ultimately, it's got to work.'

Racing green

The BTCC already uses sustainable fuel from Haltermann Carless, which introduced its R20 product to the series in 2022. It was not the first time something other than standard petrol had been used in the championship. In 2006, the MG contingent introduced a bio-ethanol fuel, while the first diesel car (a privateer BMW) arrived the following year.

The current Carless mixture consists of 15 per cent second generation ethanol content and five per cent renewable hydrocarbons. This yielded an 18 per cent reduction in greenhouse gases compared to standard petrol. TOCA wants to take those numbers further and exploration is already under way.

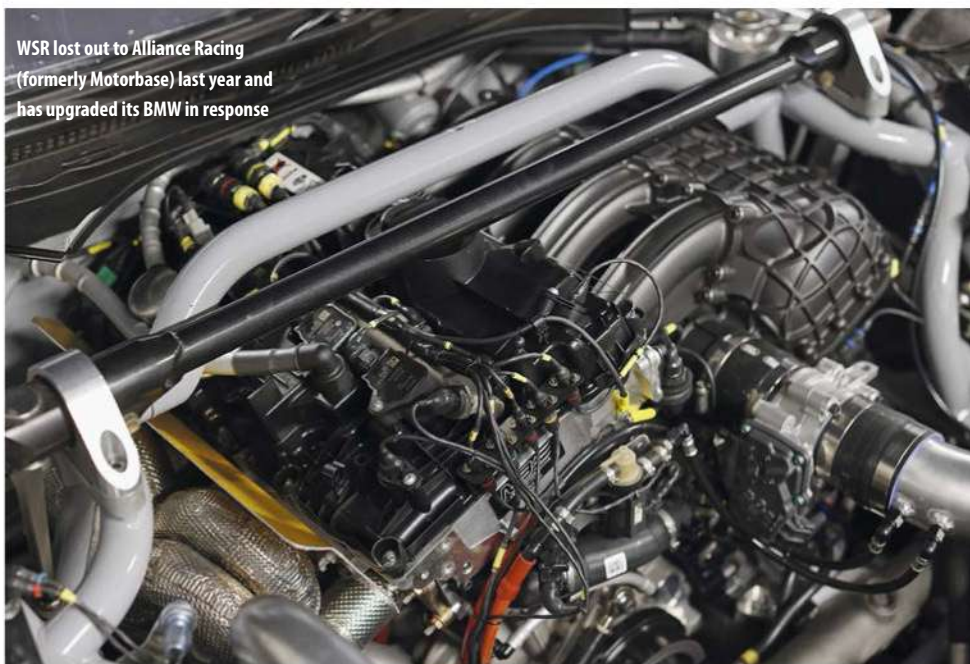
The series' engine builders – M-Sport, Mountune, Swindon Powertrains and Neil Brown Engineering (NBE) – have all been given two different blends to try out.

'We are actively testing R100, which is 100 per cent renewable fuel, with the hope of introducing that in the future,' reveals Riches. 'It's that next step. We're not putting anything new back in or creating anything extra [in terms of carbon emissions]. We will then look at going down the synthetic fuel route, but that's another challenge.'

'On top of the technical aspects are the commercial aspects. If we wanted to do that jump today, it would double the teams' fuel costs. There is always that juggling act to play.'

The vision to increase the share of sustainable fuel is part of the BTCC's push towards a zero carbon emissions target that TOCA is yet to announce publicly. Its first port of call is to reduce emissions from the racecar but, as the best-attended motorsport series in the UK, the travelling public and associated event logistics are important contributors.

WSR lost out to Alliance Racing (formerly Motorbase) last year and has upgraded its BMW in response



Some series are looking into hydrogen, and the BTCC is open to such alternative fuels, although it would likely be too expensive for TOCA to adopt out of its own wallet, while costs for the teams would also be very high.

'There is only so much of a racecar you can do that to,' says Riches of the zero-emission drive. 'We are looking at permitting new materials for the bodywork. It's traditional glass fibre at the moment, so we are looking at whether we can improve in that area, with hems and so on. All those types of things are being looked at to make the series more sustainable.'

Annual gains

As TOCA weighs up its future steps, there is also a need to manage the season-to-season technical matters of a championship where car updates are allowed. The BTCC currently permits manufacturers to make performance upgrades through a 'joker' system that must be agreed with the organisers and made transparent to the other competitors.

'WSR have done a facelift because they want to be current,' says Riches of the 2024 crop, 'but then you've got someone like ExcelR8 [Hyundai] who have done nothing externally, but a lot under the skin. They have a new relationship with Team Dynamics so they're using some of that experience.'

'Teams have a deadline to submit the things they want to do. Anything I need to consult, I consult on. We make a decision on whether we accept it, and then we advise on how many jokers it will cost them.'

'It's all detailed on the paperwork, which all of the teams have a view of. But then, when we make a regulation change, that doesn't count as a joker. If it did, they would all use up their jokers for the changes that we are making them do.'

WSR won seven manufacturers' titles on the trot for BMW until it was beaten by Ford last year. The team has updated its fleet of BMW 330e M Sports in its quest to reclaim the crown, starting with a new engine.

The B48 unit, which replaces an engine that had been active since 2017, comes from BMW's road car portfolio and is race prepared by NBE. It boasts 'several different components,' according to Bennetts.

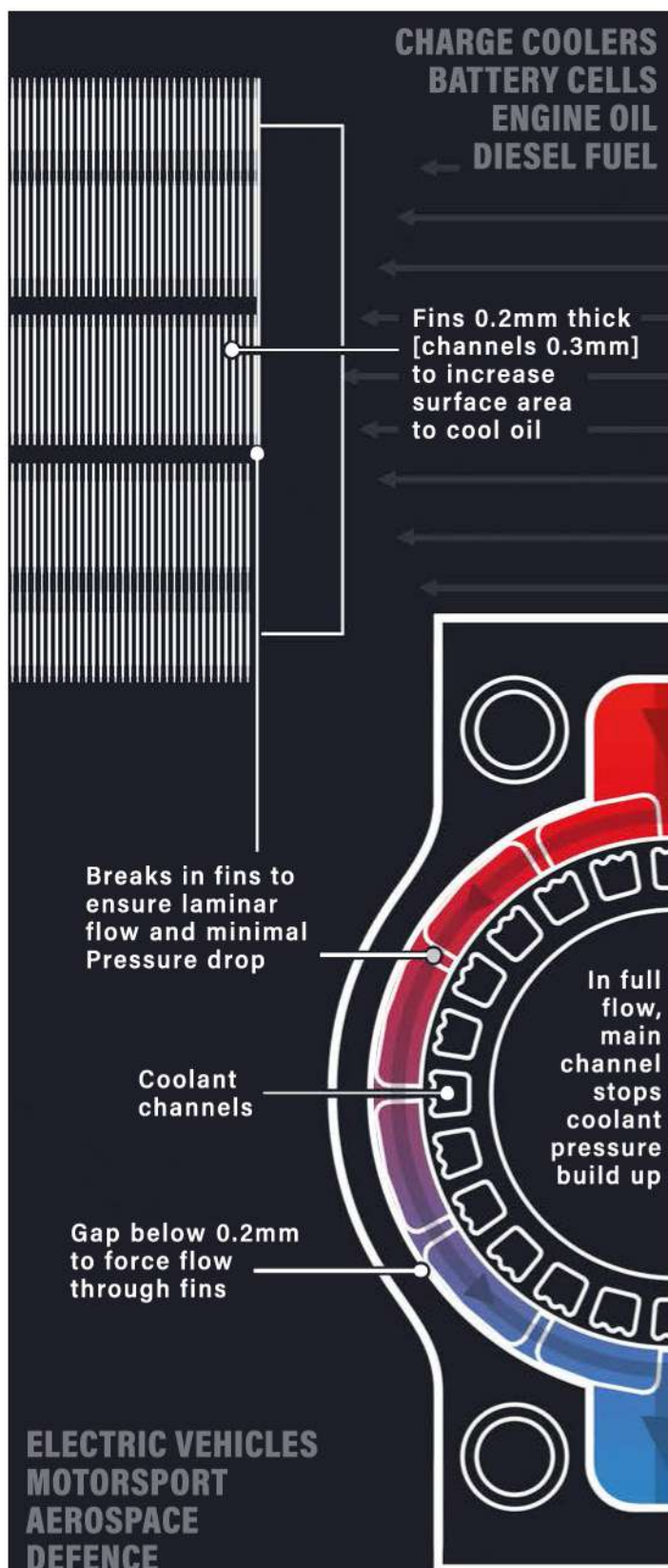
'We've also gone to a 3D printed inlet manifold,' he continues. 'We've had the same inlet manifold and airbox since 2017, so that's quite a change. Then internally, the engine has got a different water system.'

'When you see inside these engines, for a road car engine, they are very sophisticated. It's got very high fuel pressure – from 200bar to 350bar – and that's in every road car. It's not just done for racing, it's done for efficiency. Pairing cleaner burning within the combustion chamber with the higher fuel pressure injectors.'

As the facelift included new front and rear bumpers and headlights, WSR re-worked the car's ducting and water-cooling systems. , Alliance, meanwhile, has looked at improving its title-winning Ford's straight-line speed.

Although performance upgrades are closely monitored, teams cannot afford to stand still in such a competitive series.

The adoption of hybrid power was a key chapter in the BTCC's history, which started in the 1950s. It was a risk because it made the series a guinea pig in determining whether cost-effective hybrid racing was possible. At the midway point of the current rules cycle, the teams and fans have largely accepted the technology, but the success of this year's measures to improve the racing will establish whether further tweaks to the hybrid powertrain are needed in the future. **R**



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Sporting Trials is all about accuracy and car control, driving lightweight, rear-wheel drive machines up steep, twisting, often muddy sections without hitting the poles that mark the route or allowing the car to stop

ride

With fiddle brakes, propane-fuelled engines and tyres that can run as low as 3psi, Sporting Trials is a very different form of motorsport, arguably the slowest around

By MIKE BRESLIN

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In 1997, the McLaren Formula 1 team came up with a very clever tweak indeed. It involved an extra brake pedal, which acted on one rear wheel only with the purpose of reducing understeer mid-corner by inducing oversteer via 'brake steer'. Which wheel was braked depended on whether there were predominately right or left turns at a circuit.

It was a secret mod' that was rumoured by an eagle-eyed photographer, Darren Heath, who spotted brake discs glowing at unusual points in a corner, and then managed to snap a shot of the extra pedal on a McLaren that had retired from a race.

Thanks to Ross Brawn, then Ferrari technical boss, this was subsequently called a 'fiddle brake' throughout the F1 paddock.

By calling it a fiddle brake, Brawn demonstrated awareness that the technology, which F1 banned in 1998, was not new at all: it had been a key element of Sporting Trials cars for many years. In these vehicles, fiddle brakes are similarly used to help steer a car, but also as a form of traction control, to balance it while traversing slopes, and for slowing down. In fact, they are probably the most important controls on a trials car.

Before we get into that, though, what exactly is Sporting Trials?

'It's about who gets furthest up a section,' explains Ian Wright, builder of the Sherpa trials cars and a multiple champion in the sport. 'Ideally, you want to clean the section, that is get to the top of the hill without stopping or hitting any of the gates.'

There are 12 gates you need to negotiate in a section. If you clip a pole, or stop for more than three seconds, you accrue points. The driver with the lowest score wins. Oh, and the sections Wright mentions tend to be up very steep, often muddy, slopes.

'It's about who gets furthest up a section. Ideally, you want to clean the section, that is get to the top of the hill without stopping or hitting any of the gates'

Ian Wright – multiple Sporting Trials champion

The sport could be seen as a bit like an uphill ski slalom. Yet, while sometimes you do need to plant the throttle to ascend a steep slope in a section, this is certainly not about outright speed. In fact, it's probably the slowest form of motorsport there is. That said, it still offers a similar engineering challenge to most other disciplines, namely the quest for traction, momentum and finesse.

Mainstream era

While Sporting Trials is currently enjoying a resurgence, it is still wonderfully low key. Yet in the past, it was mainstream motorsport in the UK, and was even televised, while many who went on to greater things cut their teeth in the discipline – some of Lotus founder Colin Chapman's earliest designs were for trial cars, for instance.

These days there are a number of championships, including those run by the BRTDA (British Trial and Rally Drivers Association), Motorsport UK and the 750 Motor Club, with usually around 30 entries turning up for any one event.

There are two main chassis used, Wright's Sherpa and Crosslé, and what you tend to see on a typical event, such as the Walsingham Trial in Petersfield, Hampshire that *Racecar* attended in March, are these two makes, plus any number of variations on these themes, and a smattering of home-built specials.

There are limited regulations to adhere to, such as the car needs to be front-engined, rear-wheel drive and built to set wheelbase and width limits, but there is still plenty of room for technical creativity, if you're the type who likes to 'fiddle' with a car.

Fiddle sticks

It's unusual to start with the brakes in a feature on a car, or race category, in *Racecar Engineering*, but then Sporting Trials is unusual.

'You can't drive the car without fiddle brakes,' states Wright, matter-of-factly. 'Fiddle brakes are the absolute be all and end all of driving a trials car.'

'There are two of them, left and right, and they are brake levers. So, you steer one-handed using a knob on the steering wheel, and you rest your other hand on the brake levers 100 per cent of the time.'

The two levers work the rear brakes independently, and they're basically used to 'cheat' the mandatory open differentials.

'Of course, with a differential, when you slow one wheel down, the other speeds up, so it pushes the car around. If you then add a bit of throttle, if you spin that wheel up, you can absolutely pirouette the car,' says Wright.

This is vital, because most of the weight in a trials car is over the rear axle, to aid traction, so the front end is very light indeed and very prone to understeer. Which means most of the steering is on the fiddle, as it were.



Sherpa is one of the most common chassis in Sporting Trials. Cars weigh around 400kg with a distinct rear weight bias



Well-known Northern Irish Formula Ford constructor, Crosslé Car Company, made trials cars for several years and, although the company has twice changed hands since, its chassis is still a very popular choice with competitors

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Transaxles are often Formula Ford spec, from Hewland or Elite, and tend to be very close ratio. There's also usually a reduction gearbox from the engine. Double wishbone rear suspension is basic by design, but can also be surprisingly high-tech in the details

'They're also the traction control,' continues Wright. 'Here you're effectively loading the diff.'

This means the driver needs to anticipate wheelspin and apply the levers to counter it, but not too much, of course.

'The skill of it is with the feel, and not locking your wheel up,' says Alan Murton, who competes in a Crosslé, adding that the fiddle brakes are also vital for that trickiest of trials manoeuvres: traversing a steep, muddy slope.

'Going across the camber, obviously all the weight is on the bottom wheel, so you brake the top wheel to stop it spinning, which it tends to do because it's so light.'

Unsurprisingly, the calipers used are often taken from Formula Fords on the Crosslés, fitted with road pads, while on the front there are usually motorcycle brakes for the rather more humdrum act of helping to stop the car.

Super sneaky

As mentioned, differentials cannot be locked or limited slip items, and these are tested and then sealed, for good reason.

'Three years ago, it was discovered that people were using something called a super diff', which was made in America for Hewland gearboxes,' says Wright. 'It was a free diff' but somehow, miraculously – especially with a bit of wear – it would start to tighten up.' Now,

'They're probably the worst tyres on the market for the sport, but this is on purpose. If they had knobbles on them... it would be too dangerous'

Matt Sharp – Sporting Trials competitor

your car must be tested and, if you win more than five events, it is re-tested.'

Hewland gearboxes are very popular in Sporting Trials, as are similar gearboxes from Elite, and this similarity with a Formula Ford is perhaps no accident.

'The tale goes that Crosslé used Hewlands in its trials cars because when the Formula Ford boys end up backwards into the Armco, it smashes the bellhousing off,' says Richard Sharp, who trials a Cartwright, which is a sort of Crosslé replica.

'So they had loads of them in the corner, with no bellhousing on, but trials cars don't use the bellhousing. So it was a perfect fit.'

In what is a very cheap form of motorsport, these racing transaxles represent by far the biggest outlay, costing around £8,000 (approx. US\$9,960). They tend to be used in four or five-speed configuration with 'very close spaces between the ratios,' per Murton.

On most cars, the chosen engine's original gearbox also acts as a reduction gearbox and, while usually just one gear is used on a section, it never hurts to have options. Wright's own Sherpa, for example, has an abundance.

'It's a five-speed gearbox with high and low, a bit like a 4x4,' he confirms. 'Because I run the Suzuki Swift engine, I have a Suzuki Vitara bellhousing as the first part of the gearbox. I run two speeds in that – first and second – so when I'm in first I'm sending drive to the transaxle and that's my five low gears. Then, when I put it into second, I've got five high gears. So, I have 10 gears, though I only actually use seven because I'm only interested in the first and the second with the high 'box.'

'Admittedly, not many people do that. Five gears is usually deemed bloody plenty!'

While the gearboxes may be race-spec, the tyres are not, and they're not what you might expect on a dedicated off-road machine either.



The left and right fiddle brake controls are situated very close together on modern trials cars. The wheel knob is vital because, with both levers constantly in use, steering is a one-handed job



Sporting Trials cars run extremely low tyre pressures and specially developed wheels that the tyre is fixed to. The minimum pressure allowed on an event is set by the clerk of the course and can be as little as 3psi

'They're probably the worst tyres on the market for the sport, but this is on purpose,' notes Matt Sharp, who runs a Crosslé.

'If they had knobbles on them, the front of the car would be climbing up on the hills. It would be too dangerous.'

Limited options

The tyres are from the Motorsport UK list for roadgoing rubber, and there's basically a choice between a Yokohama and a Toyo product. The limitation in options is also driven by the wheel size.

'They're 15in diameter, 165/15, and we run very specialised rims because we have such low tyre pressures. So, effectively, we can't change the size of the tyres to a more convenient size,' says Wright.

'Because you're running just three, four or five psi, in the old days punctures were really common because the tyre was held on with studs, to stop it spinning [on the wheel],' Wright adds, 'but the modern cars use a wheel that I designed. There are no clamps, and you could run it at one psi.'

This wheel is a split rim and, while it was developed by Wright specifically for trials, the idea was borrowed from other applications.



Here, the outer wheel is spinning, so the passenger is transferring weight onto it to help with traction. The inner wheel, meanwhile, is braked as a course judge watches on



Note the outboard right-hand fiddle brake control on this older car, here being used to try to cut down wheelspin. Historic trials events are becoming increasingly popular

'Trucks used to run split rims so you could get the tyre off the wheel more easily,' Wright explains. 'What I did was adapt that idea so the tyre is fixed to the rim and it can't peel off.'

As for pressures, it's usually a case of the softer the better.

'If you've got hard tyres, you've got a car like a pogo stick,' says Wright. 'Also, if there were two lumps on the ground, a hard tyre is touching both lumps, whereas the soft tyre fills the gap between.'

Under pressure

'Traditionally, tyre pressures were free, but now five [psi] is the norm, and it is set by the clerk of the course on the day.'

'If it's raining, they might go down to three. We don't tend to go down lower than that any more, or above eight. That said, if the clerk says you can run three, you can still run as high as you like, you just can't run lower.'

Surprisingly, with such a low-grip tyre and surface, there is actually tyre wear, and the top drivers change the rears every five events or so.

'You're only wearing the edge off,' says Wright, 'but that edge wants to be super square.'

On the front, most trials drivers tend to use wheels and rubber from a small motorcycle.

'The front doesn't do much,' says Murton. 'Most of the time, if the car was going up a hill, you could put your foot under the front wheel and you would hardly feel it. You want the front wheels just hopping, that's ideal.'

That's not to say the front does nothing at all for, even if a car is being steered on the fiddle brakes and throttle, it still needs direction for the tight manoeuvres that are commonplace on trials courses.

With this in mind, Richard Sharp designed a clever, chain link steering system for his car.

'I get plenty of lock with it, and you don't get the over-centring on the steering wheel. It's a fairly even force required all the way.'

However, the front suspension is a beam axle on the vast majority of the cars, which is fairly unsophisticated and basically helps to control roll across the chassis.

It's at the rear where the real trickery takes place, with high-tech modern dampers such as Öhlins – on some cars in transversely-mounted monoshock configuration – pushrods and anti-roll bars, all working with soft springs.

'The set-up is reasonably soft,' says Chris Burton, who trials a Sherpa. 'If it's too hard then you're going to get too much bounce. And when that wheel is unloaded, you're not getting grip. So you need to make sure that you've not only got enough travel, but enough control over that suspension movement. So rebound is important.'

'The rebound speed is crucial as well. You want to get that tyre into full traction and keep it on the ground – it's the compression vs rebound thing – but it all comes back down to the weight of spring. If you've got the wrong weight of spring on, it's just not going to work.'

On the gas

While the suspension, at least at the rear, is relatively sophisticated, the engines are, on the face of it, somewhat less inspiring. Then again, they have proved to be up to the task over many years.

'You want a very torquey, light engine that never stalls, never coughs and never splutters. It needs to be utterly seamless,' explains Wright, who uses a 1.5-litre Suzuki Swift motor in his car.

The 1.3-litre 12v engine from the 1980s Honda Ballade / Triumph Acclaim is also popular and, while the engines are close to standard and must be under 1650cc, tuning is allowed on cams, timing and carburation, all with the aim of improving driveability.

This is because trials driving is a delicate business, usually at very low revs, almost on



Richard Sharp's Cartwright features a steering system that makes use of a chain linkage to give the car phenomenal lock. This is an unusual set up - front suspension is a regular beam axle on most trials cars



The rear suspension in Alan Murton's Crosslé is based around a transversely-mounted monoshock. Note the propane tank alongside. This car is one of a number that are now gas powered



The venerable Honda 12v is ideally suited to trials, while more modern Suzuki Swift engines are also used. Note the gas plenum on this unit



The passenger is not just along for the ride: they must work hard at all times to ensure the weight is where it's needed to help gain that all-important traction

tickover at times, but then there is still the need to nail the throttle to blast up a hill or spin the car on occasion. Consequently, engine flexibility, along with dampers, is one of the main areas of development. With this in mind, some will use a progressive throttle linkage that has more travel in the lower rev range.

This is not controlling the flow of petrol on some of the Crosslés, but rather gas.

'Crosslé dumber the engine down by putting it on propane,' says Wright. 'They run it on a forklift throttle body with a little gas tank in the back, and it goes through a regulator.'

'Dumber down' here means making it less liable to spin the wheels, by taking the edge off the throttle response. This set up is said to be easier to tune than a carburettor, though other cars still use regular petrol and carbs, while Wright has fuel injection on his machine.

Tipping point

Most chassis are steel spaceframe, or partial spaceframe, in construction. Only some are built with roll structures, but all contain a mandatory, rear-fitted spare wheel.

There are just a few tubes to hold the minimal bodywork in place, which tends to be simple aluminium or GRP panels, though some cars apparently use carbon bonnets.

While there is no weight limit, keeping weight down is important, and the best cars tip the scales at around 400kg. Obviously, weight distribution has a rear emphasis, but it's crucial not to overdo this, as Murton explains.

'You definitely don't want too much weight on the front, but you want *enough*. The car I built [before he bought his Crosslé] was too much the other way. I put the gearbox two inches further back, as there's no rule about that, but driving it was desperate. You only had to touch the throttle and it would instantly be right up on its end. I nearly flipped once. You want a balanced car.'

Helping with the balance across the car out on the sections is the passenger, though that word is misleading as the person in the second seat is certainly not just along for the ride.

Frank Willard, who trials his self-built WillKym chassis, was taking a turn in the second seat at the Walsingham Trial and explains: 'The passenger is very important. What you're doing is balancing the car the whole time and trying to move the weight to the area that is going to have least traction, the same way you do with a motorcycle sidecar.'

If people know one single thing about Sporting Trials, it is that the person riding shotgun will spend much of their time bouncing up and down to help find traction, as well as helping to navigate the course.

Some competitors are not sure the bouncing makes much difference, though.

'People have convinced themselves that it's worth doing, but we don't,' says Willard. 'There's a bit of movement but, unless you really know what the bouncer is going to do - so that you can coordinate what they're doing and where they're pushing weight down and releasing weight with what you're doing with the accelerator and brakes - it's a waste of time. I prefer to get the weight in the right place and do the rest of the work with the vehicle.'

While not all agree about the value of bouncing, they concur that experience counts for a lot in this game, and the very best car is of little use if you're not a good driver.

'You want a very torquey, light engine that never stalls, never coughs and never splutters. It needs to be utterly seamless'

Ian Wright

'I suppose in some ways it's a bit like flying a helicopter,' says Richard Sharp. 'You've got your foot going, you've got your hand going on the fiddle brakes, you've got your steering going, your ears are going, listening to the exhaust note and you're feeling what's going on through the seat. There's a lot going on.'

Sporting chance

Sporting Trials is a challenge then, but not one that's out of reach for the man or woman on the street. This is very cheap, fun motorsport.

'The cost of the season is pathetic,' says Wright. 'We're talking £50 entry fee, very little petrol each event, and a pair of rear tyres - if you're competitive - every five events.'

The price of a brand new car is a bit stronger, around £30,000 (approx. \$37,390), but second-hand examples can be picked up for as little as £2000 (approx. \$2500) and even old ones are easy to update and modify.

'These cars are everlasting. You just adapt and adapt,' says Wright. 'Because of that, the market for new cars is very subdued, though we do still build a lot of cars for historic trials.'

This is perhaps the most thriving area of the sport currently but, for those who want a technical challenge, the modern Sporting Trial scene is definitely the place to be.

'You can fiddle with a trials car to your heart's content,' says Wright. You can also build your own car, which some do, though that comes with a warning: 'Personally, I think you have to drive a car in the sport and really understand it before you amass the knowledge to build one,' says Matt Sharp.

Clearly, there's both a driving and an engineering challenge to Sporting Trials, but in the final analysis it's all about getting up that steep, often muddy slope. As Wright says: 'I think it's the challenge that attracts people to the sport. How can you get a two-wheel drive car to do seemingly impossible things.'

Race on the wild side

A close look at the faster, more extreme Trans Am cars coming out of Riley Technologies that contest the series' premier TA category

By DON TAYLOR

Photo: Chris Clark

TA cars are the wilder, outlaw cousins of Trans Am. Fewer in number on the grid, but more powerful and always pushing the technology envelope



Stepping into the Riley shop, I am immediately struck by a bright red Kar-Kraft Mk IV, a continuation car identical to the 1967 24 Hours of Le Mans-winning Ford. It's the latest project coming out of Riley Technologies of Mooresville, North Carolina. Next to it sits a Riley & Scott Mk III in for a refresh. Its spot was previously held by a Ford Mustang GTP.

These are all winning cars from designer Bob Riley's long career, but form just a small part of what goes on at the business today. Riley has never been one to dwell on what went before, or past glories. Instead he prefers to think about the future. And so, we meet in Mooresville to take a close look at Riley Technologies' latest Trans Am car.

Today, there are two classes for tube frame, silhouette body, V8 Trans Am racers. One variation is the newer TA2 specification, as detailed in REV34N4. The other is classic TA.

While the more popular TA2 class follows the path of cost containment - a top priority since its inception in 2011 - the TA class,

whose lineage stretches back to Trans Am's genesis in the 1960s, continues to run a bit more on the wild side.

Over that time, Trans Am cars have evolved within their muscle car skins, shoving and grabbing for competitive advantage by way of ever more sophisticated chassis and suspension details, wider bodies, bigger tyres and brakes, plus, of course, more horsepower.

Wilder cousin

The factory-backed competition between Detroit's car brands fed and encouraged that technical creep, leading to bulked-up body shapes and increasingly expensive components. That eventually led to a re-thinking of the series, and the creation of a TA2 branch to the Trans Am family tree.

But that hasn't stopped interest, or technical progress, in the original TA class. Although they are far fewer in number on the grid than TA2 (the two are not allowed to run together), the faster category survives.

TA cars remain the wild outlaw cousins, pushing boundaries at every opportunity. But just how ornery are they? While TA2 cars are limited to 520-540bhp and run efficient fuel injection, TA cars snort fuel through a sewer pipe-sized carburettor - like smoking an unfiltered cigarette - and have roughly 850bhp to throw at their upsized tyres and wheels.

Something they do share with their domesticated cousins is the series' ban on active suspension, telemetry, traction control and ABS brakes, both to keep them as 'drivers' cars', and to help control costs.

Riley and Trans Am

Bob Riley got his start in Trans Am by designing the all-conquering, factory-backed, Roush-Protofab Ford Mustangs in the early 1980s. His son, Bill, was involved too, working on many of the drawings for those cars while still in high school. The duo then followed that up with the design of factory Chevrolet Camaros.

TA cars snort fuel through a sewer pipe-sized carburettor and have roughly 850bhp to throw at their upsized tyres and wheels



The new AR3 cars are still traditional spaceframe design, but feature some neat innovations



Bill (left) and Bob Riley have been building racecars together for over 30 years, and in recent times have expanded into historic racecar restoration, and running cars

Photos: Don Taylor, unless stated

‘Should we just massage what we’ve already done and make it lighter and stiffer? No, let’s jump ahead about 15 years. That was the philosophy of this car’

Bob Riley, Riley Technologies

As designers of championship-winning cars, their joint talents have since been applied to a series of Trans Am car designs for many different teams.

In recent years, Bob and Bill have been designing TA cars for driver and friend, Tony Ave. The Rileys draw them and Tony builds them in his own nearby shop. Ave had built about a dozen Riley-penned Trans Am cars but, when an updated design was discussed, Ave’s circumstances during the COVID pandemic didn’t allow him to proceed.

The Rileys therefore decided to build the next-generation car themselves.

‘Bill and I asked ourselves, should we just massage what we’ve already done and make it lighter and stiffer? No, let’s jump ahead about 15 years. That was the philosophy of this car and, as a result, it is quite unusual,’ says Bob Riley.

The AR3 is the result.

The first AR3s raced in the summer of last year and, by the end of the season, had recorded eight wins and seven poles in 10 races, as well as setting three lap records.

Seven cars have been built so far and three of them were in the workshop when *Racecar Engineering* paid a visit.

AR3 chassis

Yes, it has a steel tube chassis, as per TA rules, constructed of square and round tubing. Conventional at first glance, yet this frame is noticeably narrower than previous cars across the cockpit, cowl and front structure. The sides have been dramatically sucked in, too. That does two things. Firstly, it reduces weight by using less material. Secondly, it creates a wide channel between the cockpit and the inside of the bodyshell, providing a new path for internal airflow.

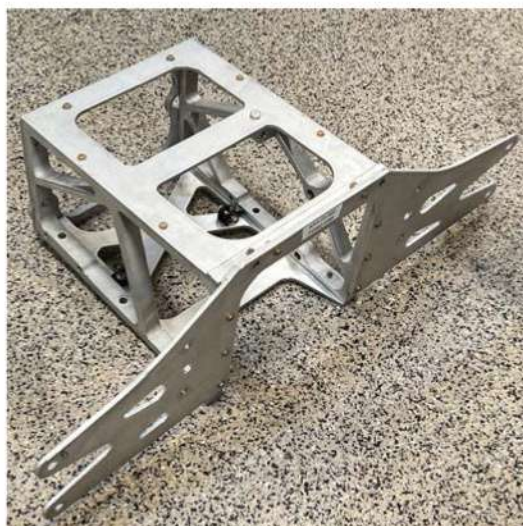
This pathway is clear, except for the jack posts and the protective door bars, which reach out to provide impact crumple space. Even with the narrower chassis, based on his torsional testing, Bob proclaims this to be ‘the stiffest tube chassis I have ever done.’

The engine bolts in via a conventional front mounting plate but, at the rear, attaches to a fixed bellhousing.

‘It doesn’t really look like a bellhousing,’ notes Bob. ‘It’s made from water jet-cut pieces,



One of several unusual features in the AR3 chassis is the split fuel tanks at the rear, which allow for finer tuning of weight balance



Some of the neatest advances have been made possible through water jet cutting technology. The bonded rear bellhousing is one example



The noticeably pinched main chassis section, with curved side protection bars, is another step change



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New for the AR3 is the use of electric power-assisted steering. Aside from being lighter, variable and more predictable at all speeds, it has allowed the steering rack to be raised up out of the path of passing airflow



With an eye on ease of running and set up, these coloured shims offer quick, easy adjustment of front ride height at the top damper mount

with sides, front and back bonded and bolted together. It stays in the car when you pull the engine, and is part of the structure, so it adds to the stiffness.'

Regarding water jet technology, he adds: 'That's such a neat tool. You cut everything with the holes already in it, and it's amazingly accurate. I was surprised how you don't have to re-machine it. You don't have to do any of that; it all just fits right together and we have one stiff unit.'

The bellhousing is also used to move the oil pump further back and out of the way to shift weight and smooth out the under-bonnet airflow around the engine.

Steering motion is provided through an electric-powered rack.

'The advantages of electric are that you can vary the load and, when you slow down, sometimes with hydraulic power steering the pump doesn't work so fast, and that makes it harder to steer. Electric doesn't do that,' explains Bob.

Riley admits the electric steering, in this case supplied by DC Electronics, is more expensive but feels it is worth it for the advantages it offers, including its fitment in the chassis. In the AR3, the rack has been moved up and out of the airstream under the car's nose. The oil pump has followed suit to help improve internal airflow.

Customer friendly

Up front, the upper and lower A arms are conventional, fabricated from tubular steel. Adjustment for camber and caster is accomplished at the upper arm with a supplied set of different thickness shims, colour coded to be customer friendly.

'The crew guys can immediately see the colour of the shims, so they don't get confused,' adds Bob.

JRi spring / shock coilover units mount on the lower arm, with ride height controlled at



By regulation, TA cars have to run a solid rear axle, but on AR3 it mounts via an innovative water jet-cut carrier

the upper mount with more shims. The front anti-roll bar's links attach to the lower arm.

In the back, Riley's first choice would have been an independent rear suspension, but the sanctioning body wouldn't allow it, insisting Trans Am remains with the long-serving solid rear axle.

'It's a shame, as independent [rear suspension] would have been cheaper, easier, faster... Nobody has a solid axle, not even NASCAR, for heaven's sake!'

Bob Riley



The anti-roll bar links, coilovers and three-link suspension all attach to the bonded aluminium carrier, which houses the third member and axles

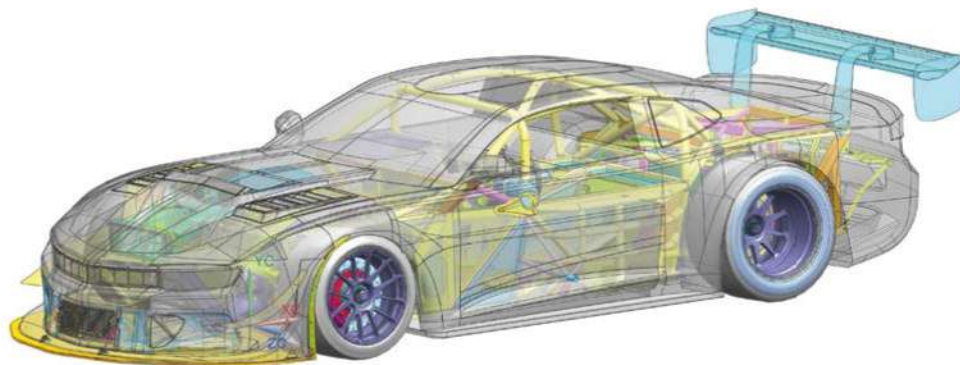
'It's a shame,' says Bob, 'as independent would have been cheaper, easier, faster... Nobody has a solid axle, not even NASCAR, for heaven's sake!'

That didn't stop the talented Rileys from trying something new though.

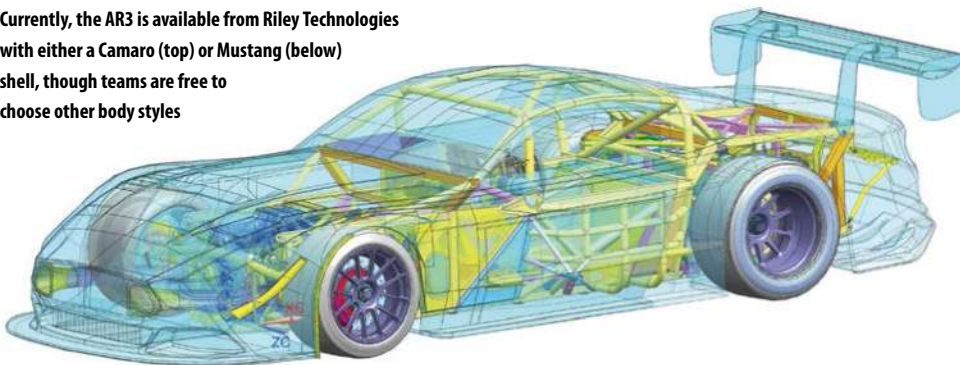
'The old ones have a pig [slang for the centre section / differential], a round tube on each side and then the upright. You connect arms to the outside and then to the pig, and the [bending and torsional] loads go through the round tubes,' Bob explains.

Something new

Figuring there was a better way of doing this, Riley has constructed a strong box section from aluminium plate, which captures the differential, hubs and axles. As with the bellhousing, the water jet machine was called on to do the work.



Currently, the AR3 is available from Riley Technologies with either a Camaro (top) or Mustang (below) shell, though teams are free to choose other body styles



CFD-designed front splitter extends under the front fascia, the narrow frame rails helping under-car airflow and helping to create downforce



Bodies must remain as supplied, but can be modified for engine bay cooling. Radiator airflow exhaust shown



Swan neck rear wing mountings help in yaw situations by blocking and increasing pressure, but don't interrupt airflow to the wing

'You don't need the welder and we save quite a bit of weight there, too.'

The 'three-link' rear suspension arms and the anti-roll bar links mount to this box, along with the coilovers, which fix at the top.

'I hate to see that rollage just going along doing nothing – unless you're upside down – so the springs attach up high where there's a lot of structure, and that adds to the structural continuity, and also dampens some of the roll.'

Lateral axle location is provided by a traditional Watt's linkage, chosen to place the roll centre as low as possible in the rear.

'You need to get that really low,' states Bob. How low? 'The bolt that holds the Watt's usually hits the ground,' he replies.

Rear suspension adjustments are made in the same way as at the front, using coloured shims to adjust toe-in and camber.

'What we've found has worked best is a degree and a half negative camber,' says Bob.

As for rear toe-in, so far, the car seems to work best at present with the wheels pointed straight ahead.

Riley admits to having had early drive axle failures during on-off throttle loading, but that was easily and promptly resolved.

'When you do something completely new, it's naïve to think you won't have any issues,' says Bob sagely.

Another new component that has been very successful is the wheel bearings.

'We had been working with SKF, and they make a bearing pack for us, for our hub design. So now we sell a bearing pack, so you don't have to take the bearings apart and re-grease them all the time. We've had very good luck with that. As far as I know, they've never gone bad. They are more expensive, but they're also lighter, and you don't have the maintenance issue.'

Also unusual in the rear section is the pair of fuel tanks. One of them is mounted in front of, and one behind, the rear axle, allowing for better balancing of front / rear weight distribution.

More conventional are the brakes, the cars equipped with six (front) and four-piston Alcon monoblock calipers and iron discs.

Body and aero

The body construction is composite carbon fibre, Kevlar and glass fibre. Riley Technologies offers the AR3 with either a Chevrolet Camaro or Ford Mustang body, although other body styles are allowed in TA.

Standard wheelbase is 102in, but may vary slightly depending on the model. Maximum car width is 80in, with a total length, including splitter, of just under 200in.

As in TA2, the bodies in TA are acquired from a single designated supplier, in this case Kerry Hitt's Advanced Composite Products, and are to remain untouched.

Riley Technologies today

For the last 30 years, father and son, Bob and Bill Riley, have operated very successfully as Riley Technologies, moving from Indianapolis to Mooresville, North Carolina in 2006.

However, like many racecar designer / constructors these days, they have watched various series go to spec chassis regulations, limiting the opportunities for the design, build and sale of low volume racecars. Riley Technologies has therefore needed to be proactive in finding other avenues of income.

When long-time customer, Jim Matthews, acquired the rights to the drawings, parts and fixtures of the old Ford Kar-Kraft operation, he came to Riley to build continuation Kar-Kraft Mk IVs. Kar-Kraft was an independent entity from Michigan that Ford used for its racing programmes in the 1960s. Many of the items that Matthews possessed were first drawn by Bill when he worked at Kar-Kraft 60 years ago.

The first completed Riley Kar-Kraft Mark IV debuted at the Amelia Island Concours in March this year, and orders are already lined up.

The company is also undertaking historic racecar restorations, and recently finished one of two 1983 Mustang GTPs – a front-engined, ground effect IMSA racer, designed by Bob during his time at Ford.

While Bob has been actively involved in overseeing the recreation of parts and tooling for these two vintage projects, he can't stop thinking about producing new racecars like the AR3.

As a reminder of the more recent Riley vehicles and company successes, on the office wall hangs a poster which celebrates 18 overall and class wins at the Daytona 24 Hours. At its foot sits the Ligier JS P320 that won the LMP3 category in 2022, operated by the Riley Motorsports race team led by Bill.

Race team operation has become a fruitful division of the business, and is a natural fit with the talent and experience on hand. 'On the track engineering side, we have some really strong people,' says Bill. 'And, if they need something made, or something looked at in CAD, they can lean on the Riley Tech group.'

Bill and his team are currently kept busy overseeing a wide range of customer cars in four



One of the many current projects is building these period-correct Kar Kraft Mark IV racers for FIA historic competition



different US racing series: the IMSA SportsCar Championship's LMP2 class; IMSA SportsCar Challenge GT4 with Porsche; SRO GT World Challenge America, and GT America (GT3 with Mercedes-AMG).

As if all that competition isn't enough, just for fun on rare off weekends, Bill is currently building a low-buck, salvaged Corvette for ChampCar, a grassroots endurance racing series for time-honoured vehicles costing US\$500 (£400) or less.

Unfortunately, that busy schedule leaves Bill with less time these days for his first love, racecar design.

'That's still what I enjoy doing the most but, with the way the business has evolved over the years, I'm not as involved in that as I would like to be,' he says.

Still, all the work Bill does with the day-to-day running of the company frees up Bob to sit at his drawing board every day, thinking up solutions for the next challenge that comes through the door.



Riley Technologies engineers, Christian Rushforth and Chad Boyd, on the office tour



In 2006, the company relocated from Indianapolis to this purpose-built facility in Mooresville, NC

The Riley cars abide by this rule, except for the approved addition of bonnet venting, which allows radiator exhaust air to be ducted out through the top of the bonnet, another new direction on the AR3.

Unlike the aero limitations in TA2, the splitter and rear wing execution are given some leeway in TA. The AR3's splitter has therefore been extended under the front fascia. The narrow frame rails help smooth the under-car airflow and create downforce.

'We did some CFD on the splitter and, to make it work, we needed to narrow up the front,' recalls Bob.

The powerful rear wing is another Riley creation, as Bob explains: 'Wing design is open, so we did the profile for it, and this wing is pretty aggressive.'

It features twin swan neck mountings, which help in yaw by blocking and increasing pressure on top, while also not interrupting smooth airflow to the low-pressure bottom side.

The first AR3 car, which was shown at the 2023 PRI Show, had what the Rileys call a 'roof door' – a hinged panel that swings up above the driver's compartment. This was a purely practical consideration, as Bob explains: 'I thought maybe since the cars are hard to get into, I might be able to attract

If the Next Gen NASCAR Cup cars were to be considered heavyweight fighters at 3200-3400lb, this latest TA car might be thought of as a welterweight at 2830lb

more customers if there is a way to make them easier to get in and out of.'

Beside the possibility of appealing to larger frame drivers, the feature does have an added safety benefit of allowing better access for trackside emergency workers.

NASCAR lineage

TA cars are powered by 358ci (5.9-litre), carburettor-fed, naturally aspirated, pushrod V8s making around 850bhp. Several NASCAR Ford and Chevrolet race engine builders are ready to supply this type of engine, as it has long been their stock in trade.

Though not exclusive, the options are typically the Ford FR9 or D3, or the Chevrolet R07 package, all of which were originally developed for NASCAR Cup use.

To handle the power and torque of those mighty mouse motors, transmission choices are either the six-speed Xtrac model P559 or the five-speed Emco EG55. And hey kids, no paddles! These are both manual gearboxes, sequentially shifted by a lever and a busy right arm.

If the Next Gen NASCAR Cup cars were to be considered heavyweight fighters at 3200-3400lb, this latest TA car might be thought of as a welterweight at 2830lb, including driver. With each having approximately the same muscle on tap, one can easily see why the AR3 might be fun to drive. And it is, according to stalwart racers like Gar Robinson and Chris Dyson.

Nevertheless, while TA2 fields are regularly filled with 40-45 cars, only about 10 TA cars currently compete in the Trans Am's separate TA / XGT / SGT / GT multi-class races. Clearly, Trans Am series management has a good thing going with the TA2 product. The question is, will they be willing to try and grow TA as well?

Forever the forward-looking optimist, Bob Riley shrugs and says: 'I remember one guy telling me Trans Am is like a bonfire from our youth. You think the fire is out and then it flares up again, so maybe that's what will happen to the [TA] series.' **R**

TA cars are powered by 850bhp, NASCAR-spec, pushrod V8s and use either six-speed Xtrac or five-speed Emco transmissions. These are manually shifted, of course



Coupé de class

The creation of the FIA GT Championship prompted Mercedes-Benz to build a new racecar for 1997. The CLK-GTR was the German manufacturer's impressive answer

By KARL LUDVIGSEN

Mercedes-Benz has always had a knack for designing and building handsome, two-door coupés, from the older 220 saloons to the modern S-Class, combining sporty looks with high equipment levels and an extra touch of customer-pleasing quality.

This tradition was well upheld by the CLK coupé, launched by Mercedes-Benz for the 1997 model year. Based on the C-Class platform, the CLK's handsome shape and new, three-valve, 3.2-litre V6 engine 'awakened passions', as company chief, Helmut Werner, said at the time, both within and outside Mercedes-Benz AG.

The new CLK also 'awakened passions' at Affalterbach, north east of Stuttgart. There, in 1996, the racers of AMG were giving thought to their plans for the 1997 International Touring Car Championship (ITC) season.

Much as Opel had used the Calibra coupé as the basis for its DTM / ITC car, this avenue also seemed open to Mercedes-Benz.

Styling study

'We did a styling study for an ITC car related to the CLK,' engineer, Gerhard Lepler, said, 'to show the members of the board what such a car could look like. This was done using the basis of an old 1994 DTM car, on which a new body was fitted.'

However promising the mock-up looked, it became redundant with the expiration of the short-lived ITC at the end of 1996.

In the meantime, motorsports chief, Norbert Haug, and his colleagues had been tracking developments at the FIA in the field of Grand Touring, or GT racing, which pitted high performance sportscars with closed coupé bodies against one another.

Since 1994, the BPR Global GT Series had been privately run, but proved so successful



This was the first C297, known as the CLK-GTR, identifiable by its Mercedes-Benz windscreen banner. It was ready end of March 1997

On [the day] the FIA officially announced it would conduct a GT championship series... the board of management [at Mercedes-Benz] approved the design and build of a GT car



Bernd Schneider at the wheel of this CLK-GTR, a machine that set the bar for GT racing during the first year of the FIA GT Championship



Seen next to its CLK road car inspiration, the CLK-GTR appears only about half its height, measuring in at just 43.3in high. A roof-mounted scoop directed air to the engine, and added a useful bit of height to ensure the rear wing conformed to FIA regulations

that, in November 1996, the FIA told the competition organisers that GT car racing would now come under their direct control.

Word of this impending new initiative by the sport's ruling body was quick to reach the ears of Mercedes-Benz, and in particular the engineers at AMG who found themselves at a loose end after the collapse of the ITC.

'I pushed for a GT programme,' said Haug, 'on the basis that if the FIA GT Championship develops in the right way – if we get good marketing, good television exposure, all these things – then we should be involved.'

Concept layouts were quickly prepared of mid-engined GT cars with a resemblance to two production models, the SLK and CLK.

'We started with the SLK,' said Haug. 'But then, for marketing reasons, we changed to the CLK,' added Lepler.

'In adapting that shape for the GT car, it became stretched and lowered, which changed the appearance a little, but it was not that much different to how an ITC CLK would have appeared.'

As a result, both AMG and Mercedes-Benz were well prepared when, on Friday 6 December 1996, the FIA officially announced it would conduct a GT championship series in 1997. On that same day, according to Haug, the board of management approved the design and build of a GT car.

Rapid response

No quicker response could be imagined. Speed was of the essence, because the first race of the new, 11-event GT series would be at Hockenheim in mid-April 1997.

Tight timing dictated many of the design characteristics of the new car, which was codenamed C297, were shared with the 1996 C-Class racer, including its front-mounted cooling system and suspension layout. AMG, however, had to find a fast, yet valid answer for the C297's engine and transmission.

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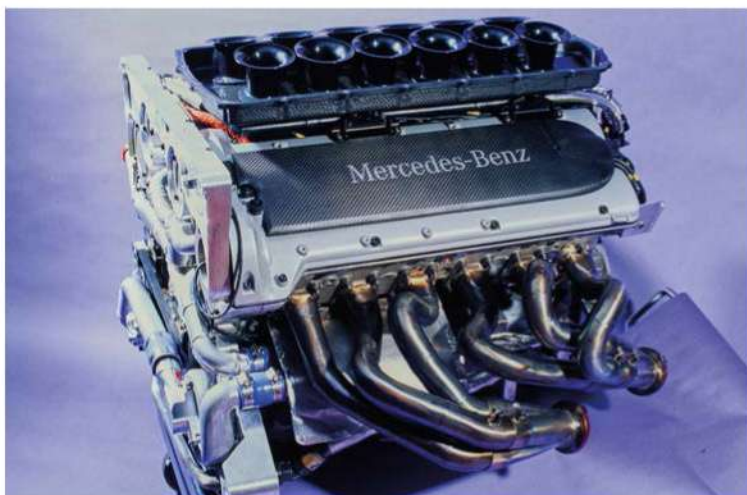


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After testing several options, the AMG engineers at Affalterbach decided that a 6.0-litre V12 was the optimum size for the power unit. This is the test engine mounted in a McLaren chassis



With an aluminium cylinder block and heads, and a compression ratio of 12.5:1, the V12 was capable of 8400rpm, though produced its peak power of 630bhp at 7000rpm



A side view showed the V12's blended exhaust pipes and the compactness of its Xtrac transaxle. Mobil 1 synthetic oil was used in both the engine and transaxle



The FIA's rules set out a matrix of six engine displacement classes and nine car weight brackets. For each combination of displacement and weight, the rules specified the diameter of either one or two circular orifices, to the designer's choice, through which inlet air had to pass. The orifice(s) had to be made of metal and be at least 3mm long.

Engine challenge

This presented a challenge for AMG's engine guru, Erhard Melcher. Which combination of displacement, type and inlet orifice would give the best results?

Having considered the options, the AMG engineers turned to an engine they knew well, the powerful Mercedes-Benz M120 V12. Here was a direct link to an impressive, high performance GT car Mercedes-Benz had built and shown in 1991, the C112.

In its own engine shop, AMG produced modified versions of this aluminium block engine, up to and including the 7.3-litre version that was available in AMG versions of the S-Class saloons and SL sports road cars.

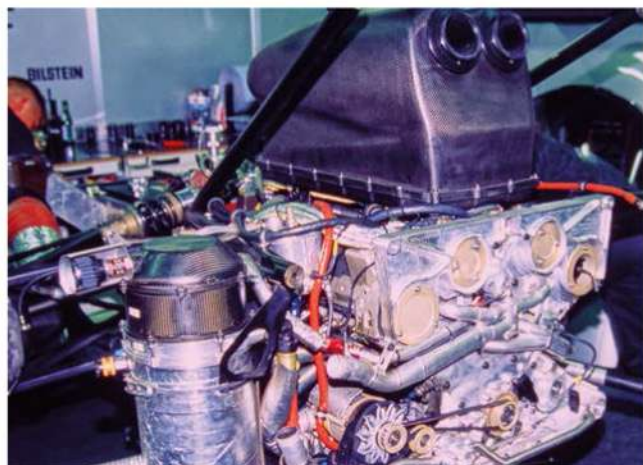
But what size should the C297's engine be? Taking no chances, AMG built and tested V12s in racing tune with 5.0, 6.0 and 7.0-litre displacements. The first engine in this series went on the test bench on 21 December 1996.

'We revved the 5.0-litre over 10,000,' remarked Melcher, yet there was a compelling reason to choose the 6.0-litre version instead, linked to the fact that Mercedes-Benz had developed the V12 as part of a modular family of engines that all shared the same cylinder size, cylinder spacing, block height and four-valve head design.

More than a year previously, AMG had looked at the M111 four-cylinder unit as a possible powerplant for an entry in the popular European Super Touring series.

'We made two such engines as a test,' said Melcher, 'and we carried out all the pre-development for the V12 on these engines.'

There was no change made to the valve angles, 25 degrees either side of the vertical.

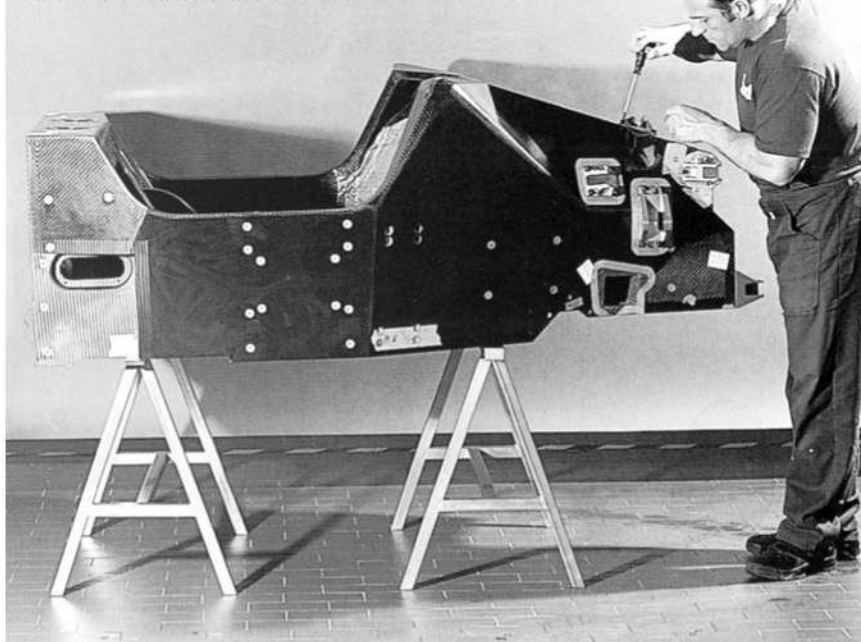


A view of the front of the C297's V12 showed the belt drive to its alternator, positioning of its four camshafts and the twin restrictors in the induction hood



At the rear, the coil springs were in compression, concentric with the dampers. The Xtrac transaxle had its gears placed transversely, underneath ancillary equipment

Britain's Lola Composites made the car's carbon fibre monocoque, to which the engine and its braces were attached to constitute the rest of the chassis



At the front, twin split radiators were positioned at an angle to cool the powerplant. Low ducts behind them vented pressurised air to the sides of the car to encourage downforce



Six-piston calipers gripped the internally drilled carbon brake discs. Diameters were 378mm in front and 356mm in the rear. Here the front spring units are installed



The orange duct brought cooling air to the fluid reservoirs of the two rear dampers. Pull rods from the hub carriers operated the springs through pivoting aluminium rockers

Initially, the V12s ran with standard crankshafts, connecting rods and Mahle pistons, though the forged crank was later lightly modified for reliability.

The heavy, cast aluminium inlet manifold of the stock engine was replaced by carbon fibre trumpets for each cylinder. Butterfly throttles were used, below which were electronically-actuated, solenoid-type fuel injectors. These and the ignition were controlled by a Bosch Motronic 1.2 system.

For the racing engine, the standard 89mm bore was slightly enlarged, the final spec being 91 x 76.7mm for 5986cc. Power output was quoted as 630bhp at 7000rpm, with 700Nm of torque at a moderate 3900rpm.

Transaxle choice

Another daunting challenge, in view of the short timeframe, was the selection of a suitable transaxle to accompany the V12 engine. Like the latter, it had to be suitable for

[AMG] subcontracted tub manufacture to an experienced outside supplier, Lola Composites

both a road car and a racecar, which disqualified the effective, but over-engineered (for this application) unit developed by Mercedes-Benz for the turbocharged Sauber-Mercedes C11 of 1990.

AMG also desired a compact unit that would work with the long V12 without unduly extending the wheelbase of the new GT car.

'For the chassis people, the V12 was a real problem,' admitted Melcher.

The search for a workable unit led the development team to Mike Endean's Xtrac concern in Britain. Fortunately, it had an appropriate gearbox sitting on the shelf.



Carbon fibre ducts from the rear deck collected air that went through large diameter hoses to help cool the car's rear brakes. A wide rear diffuser extracted air to promote rear downforce



Shown in ribbed, wet weather form here, tyres were 280/35-18 in the front and 330/40-18 in the rear. An antenna for communication with the team in the pits was essential equipment



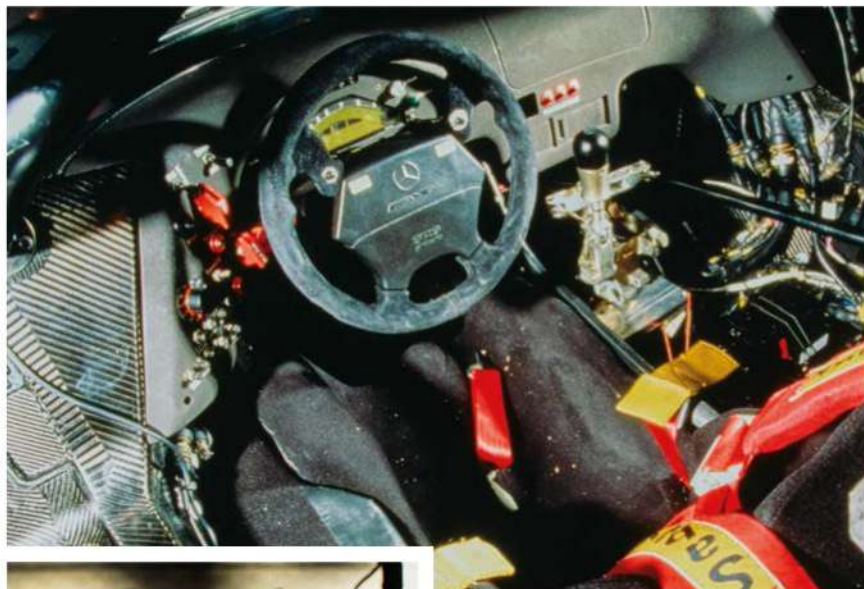
Attachments at the front of the monocoque carried the car's parallel, uneven length wishbone front suspension. In this shot, the concentric spring / damper units are not installed

Here's why. In 1993, Peugeot had decided to upgrade its 905 sports prototype to defend its 1992 victory at Le Mans against Toyota. After the '93 race, the team's sports director, Jean Todt, would take up a new post with Ferrari and the French manufacturer wanted a successful end to his career in its home country.

Consequently, for the 1993 Evo 2 version of the 905, Peugeot commissioned a brand new transaxle from Xtrac. It was designed by former Ferrari engineer, Enrique Scalabroni, to stand up to the 600+bhp, 3.5-litre V10.

'We had to make everything. All we could use from the CLK were the door handles and the star'

Hans Werner Aufrecht, founding partner at AMG



The C297's steering wheel had a small safety airbag in its centre. Minor controls were on the driver's left with the sequential gear shift lever on the right



A purposeful array in the driver's eyeline focused on the digital tachometer, while a red lamp indicated oil pressure, or the lack of it

The unit's design was modified by Xtrac to suit AMG's needs, including its aluminium housing and clutch-type limited slip differential. A big, high-mounted cockpit lever for the driver was pushed forward for downshifts and pulled back for upshifts.

Small hearted

The remarkably small heart of the C297 was a carbon fibre monocoque. Characteristics of the carbon tub included a built-in cavity at the rear to carry the 100-litre fuel tank behind the driver's seat and a narrow footwell that required occupants to offset their feet to the right of the left-hand seat position. This compromise was accepted in order to keep the car as short as possible.

'AMG does not have the facilities or capability to make a composite monocoque,' Lepler explained, continuing, 'AMG has never had a production line for carbon technology.'

Therefore, the company subcontracted tub manufacture to an experienced outside supplier, Lola Composites.

Suspension at both front and rear, the special responsibility of AMG's Klaus Fornstein, was by wide-based, fabricated steel wishbones. The parallel wishbones were close to equal length at the rear, where each upper one had an adjustable strut for setting toe in.

At the front, the upper wishbones were shorter to provide the required camber change characteristics with jounce.

As in the C-Class racers, the front torsion anti-roll bar was a hollow tube of carbon fibre. Another point of similarity with the C-Class cars was the pull rod springing on the C297.

Power assist was provided for the rack and pinion steering gear, mounted forward of the

front hubs. It had a 12:1 ratio and required one and a half turns of the steering wheel from lock to lock.

Inset into the top of the wheel were four green lights. If one lit it showed the associated road wheel was locking under braking. This helped the driver function as a kind of onboard ABS system. The driver could also press buttons on the steering wheel to select either a lean or rich alternative fuel / air programme, depending on racing conditions.

Additional cooling was required to cope with the carbon / carbon brake system, the pads and disc surfaces of which were supplied by Carbone Industrie. Each carbon ring was bolted to an aluminium carrier disc, and cooling air was ducted to the front brakes from an inlet behind the Mercedes grille, giving it a functional and aesthetic purpose.

Body building

Making the body for the C297 was no small challenge, stressed Hans Werner Aufrecht.

'We are accustomed to making a completely new car for each season, but in the past we could rely on carrying over some standard parts, such as the windscreen. When we made the GT car, we didn't even have that. We had to make everything. All we could use from the CLK were the door handles and the star.'

AMG explored various suitable shapes before settling on the stunningly handsome and Mercedes-like lines of the C297, soon to be officially named the CLK-GTR.

'The shape of the car was related as much as possible to the look of a standard, roadgoing CLK,' noted Lepler.

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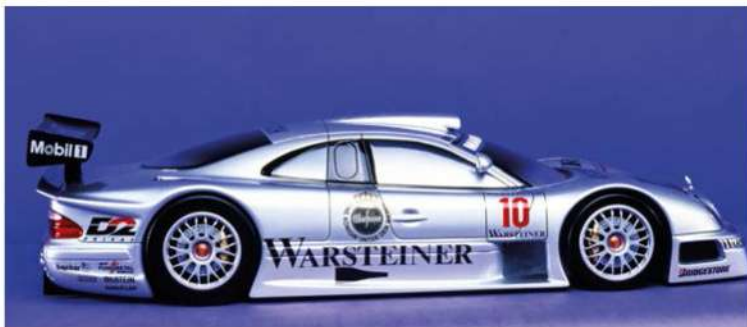
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Two views of a model that reflected the final design of the CLK-GTR, with elements of its livery included to show how various sponsor and supplier names would be placed

Requiring a completely flat bottom from the front wheels to the rear, the GT rules were designed to make it difficult to obtain downforce from ground effects.

'I would even say that there may have been less downforce than we had on the ITC cars, where the rules were far less restrictive regarding the aerodynamic shaping of the undersides,' Lepler commented.

Selectable wing

Rear wing design was relatively free on the racing version, provided it was only single element, fitted within the car's width and plan view and was no higher than the highest part of the body. The latter criterion was assisted slightly by the use of a roof-mounted scoop to draw in the engine's air, which added a little extra height that could be exploited in the position of the wing.

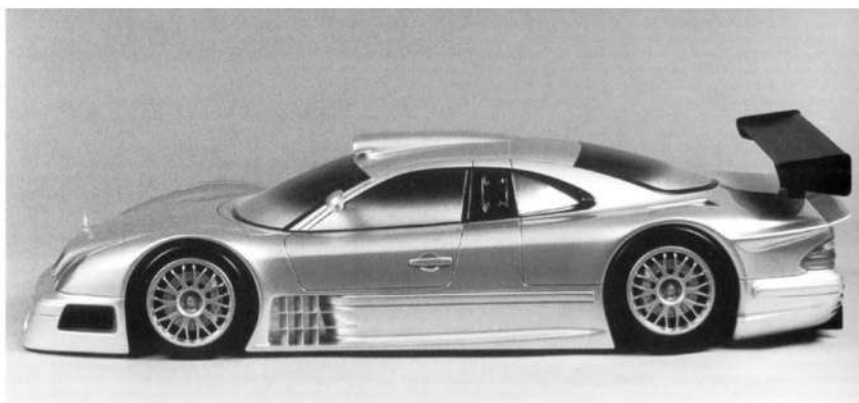
The GT rules were designed to make it difficult to obtain downforce from ground effects

The C297 was homologated with a rear wing with what the team described as a 'selectable high downforce mode.' That is to say it had two positions, one of them with the wing more steeply angled.

With the rear wing giving AMG's engineers their main opportunity to generate aerodynamic downforce, the C297's weight distribution was deliberately biased toward the rear, 40 / 60 per cent, though with the driver and a full fuel load on board, the distribution was closer to 45 / 55.

Only after the first monocoque was collected from Lola Composites on the last day of February 1997 was it possible to start assembling the first CLK-GTR from the many bits and pieces that had been arriving at the race assembly shop at Affalterbach.

Meanwhile, the midnight oil was being burned by the Mercedes-Benz homologation experts. Their task was to gain acceptance by the FIA of the CLK-GTR as a production sports car so it could compete in Class 1 of the new GT series. To achieve this, C297 number 001



Designers of the CLK-GTR's shape used models to try out design concepts. In this version, an air exhaust vent behind the front wheels was egg crate grilled, an amenity that was not ultimately employed in the final design



To gain FIA approval, a sample was needed of the road car from which the CLK-GTR was (in theory) derived. It was an extremely impressive machine in its own right, although Mercedes had to produce a minimum number in 1997

had to be designed and built to look like the production version but, at the same time, serve as the racing version.

Board approval

Hockenheim was booked for a first functional test of the completed car on 25 March, but this date was missed as the car was not ready. Nevertheless, it was near enough completion for the Daimler-Benz management board to assess. It was very impressive, they had to admit, and, by the following evening, the board gave its approval for an official GT series entry by Mercedes-Benz.

Car number 001 was wheeled aboard AMG's transporter for the journey south-west across France and over the Pyrenees to the Jarama circuit near Madrid in Spain. Completed on 27 March, the trip allowed

Bernd Schneider to give the new car its first proper workout on Good Friday, 28 March.

'Compared with the C-Class I drove last year,' said Schneider, 'this is a real racecar. It's nice to have the engine behind you, the car feels very controllable and responsive.'

Meanwhile, the German homologation authority, the TÜV, had been undertaking its tests to validate the CLK-GTR with the road car technical requirements and, on 4 April, the Flensburg vehicle registration office awarded the C297 a provisional type approval number.

Next, a meeting was convened at AMG on 7 April for an inspection of the car and its credentials by officials of the FIA. They ruled the car's homologation for racing was valid from 1 April 1997, provided Mercedes-Benz completed its road car type approval process by the end of that year.

The road was clear for an entry of two cars in Hockenheim's four-hour race. While the second car was still being completed, the driver cadre was selected. Bernd Schneider and Bernd Mayländer were signed, as were fast rising Austrian racer and Le Mans winner, Alexander Wurz, along with Marcel Tiemann, who had won the 1996 Monaco Formula 3 race (an important showcase for new talent).

Later in the season, a surprise returnee to the AMG strength would be announced: Klaus Ludwig, back after his 'outlaw' seasons with the Opel DTM / ITC team.

Instant hit

Cynics who said Mercedes-Benz and AMG had tried to do too much too soon took satisfaction from the results at Hockenheim. The new car's performance was indisputable. Schneider put his on pole three quarters of a second quicker than the best McLaren, while the sister car was fourth fastest. However, in the race itself, one car retired early with a defective brake pad and the other had to endure a 50-minute pit stop to replace a starter motor that failed from overheating.

Like Hockenheim, the next two races at Silverstone and Helsinki saw victories for the BMW-engined McLaren F1s, competing in their third season. In Britain, the outcome was close, with a CLK-GTR taking the lead just after the lap on which the race was officially declared over due to heavy rain.

The stresses of racing revealed some transmission flaws that impaired the results in Finland so, while its rivals decamped to France for Le Mans, AMG used the month of June to sort out the teething troubles evident in the brand new CLK-GTR.

Mercedes-Benz dominance was total in the next four-hour race on 29 June at the Nürburgring. From his third pole position of the year, Schneider took his coupé into a lead it never relinquished. Partnered by Ludwig, at the finish line he had lapped the best McLaren-BMW in third place. Another CLK-GTR came home in second.

The McLarens fought back with a victory in a wet race at Spa three weeks later, but Schneider salvaged a second place to become the best Mercedes points scorer.

In August and September, three one-two finishes followed for the AMG V12s at the A1-Ring, Suzuka (a race of almost six hours) and Donington. Schneider narrowly led in the drivers' points, but McLaren's Steve Soper and JJ Lehto were close on his heels. With a victory in the next race at Mugello, a race that saw Schneider pushed into a gravel trap and Ludwig's car suffer a broken power steering pump, they jumped into the lead.

The two final races of 1997 that would settle the championships were far away in America in October. To strengthen Schneider's points chances, AMG decided to pair him with a driver of proven quality, Klaus Ludwig. This strategy worked well. The pair won the races

At [Laguna Seca], the three Mercedes-Benz took the top three grid positions and finished one-two-three, a perfect end to a very competitive season



Top drivers raced the CLK-GTR including Mark Webber and Ricardo Zonta, paired with old hands Klaus Ludwig, and Jean-Marc Gounon

at Sebring in Florida and at Laguna Seca in California. At the latter, the three Mercedes-Benz machines took the top three grid positions and finished one-two-three, a perfect end to a very competitive season.

Double tops

Schneider subsequently became the FIA GT drivers' champion with 72 points, ahead of Soper and Lehto, who tied with 59 each.

In the teams' championship, AMG Mercedes placed first with 110 points. Second was Team BMW Motorsport on 85, while Gulf Team Davidoff came in third with 37, both racing the McLaren F1-GTR. Porsche AG, competing with its radical new 911 GT1, managed only three podium finishes all year and was fourth with 35 points.

At Laguna Seca, AMG and Schneider recognised the contributions every member of the team had made to the remarkable season by giving them all rides in a CLK-GTR around the hilly, dramatic track. Schneider did this in three solid hours of driving on the Monday following the race, lapping in times only about two seconds slower than he and Ludwig had averaged to win the race. **R**



Mark Webber and Bernd Schneider drove their CLK-GTR to victory at Silverstone on May 11 1997, the latter declaring the lithe Mercedes-Benz 'a real racecar... very controllable and responsive'




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The wild frontier

The challenges of managing energy in Formula E

By GEMMA HATTON

Formula E continues to be labelled ‘too quiet’ and ‘not fast enough’ to be deemed ‘proper’ racing. Yet the on-track action is more competitive than most championships, while the engineering behind the scenes is arguably more challenging and technically relevant to today’s automotive sector than the likes of Formula 1. Not convinced? Please read on.

From the outset, the format of Formula E has been carefully orchestrated to prioritise the efficient use of energy from the battery. Throughout its nine seasons, and three generations of cars, the regulations have continued to limit the amount of energy available during a race, forcing teams to use the available energy as efficiently as possible to reach the finish line. Ideally first.

Although this doesn’t sound particularly thrilling on the face of it, it is analogous to managing the tyres in Formula 1, or fuel saving in endurance racing. Motorsport regulations are designed to limit teams in one way or another, so they have to manage their pace using a variety of strategies, which is the key ingredient for an exciting race.

However, in addition to managing energy, Formula E teams also must keep the battery within an optimum temperature window, maximise the amount of regen, manage tyre performance and attack modes, all whilst controlling a hot-headed driver fighting for position. This is what makes Formula E racing so demanding for the engineers working in it and fascinating for the fans watching it.

Limited energy

So, why do teams need to manage energy in the first place?

‘The simple reason is, we start the race with less energy than we need to complete it,’ explains Roger Griffiths, team principal at Andretti Formula E, which won last year’s driver championship with Jake Dennis.

‘We start with approximately 25 per cent less energy than we need so, if we ran flat out, we wouldn’t get to the chequered flag.

That is why we need to save energy during the race and also get that back through energy management techniques.

‘These include recuperating energy under braking, saving energy during lifting and coasting, as well as optimising where we accelerate, decelerate and deploy energy for overtaking.

‘We also take into account the effect of being in the slipstream, which is becoming particularly important in Gen3.’

Ahead of each race, the FIA releases the total number of race laps and the total energy allocation (in kWh) teams are allowed to use to complete the race. These figures are based on simulations and feedback from the teams and suppliers, but typically target a race time of around 45 minutes.

Teams then use this information to calculate the total amount of energy they need to save throughout the race, as well as the most efficient way to save this energy per lap. It’s more complicated than that, though.

To explain this process in more detail, let’s assume the FIA has specified a race distance of 36 laps and 37kWh of available energy. If a lap of the track flat out consumes 1.3kWh of energy, then the total amount of energy needed to complete the 36-lap race is $36 \times 1.3\text{kWh} = 48\text{kWh}$. Simple.

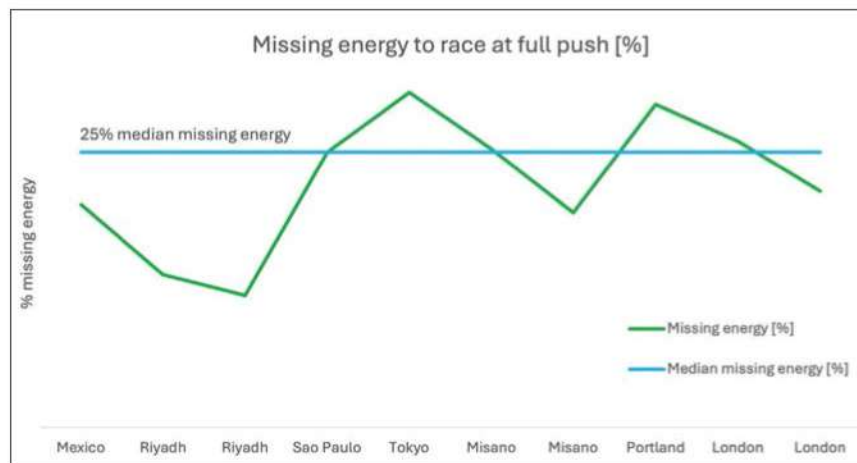


Figure 1: The percentage difference between the allocated race energy and the energy required for a flat out race



Formula E cars start with approximately 25 per cent less energy than they need to complete the race, so energy management is not only key to winning; it is critical to completing the race distance

Formula E teams also must keep the battery within an optimum temperature window, maximise the amount of regen, manage tyre performance and attack modes, all whilst controlling a hot-headed driver fighting for position

Except the FIA's energy allocation is only 37kWh. So, if we drive flat out at 1.3kWh per lap, $37\text{kWh} / 1.3\text{kWh} = 28.5$ laps. It doesn't take a mathematician to realise we will run out of energy on lap 28 of a 36-lap race.

Therefore, to finish the race, we need to save $48\text{kWh} - 37\text{kWh} = 11\text{kWh}$ of energy, which is 26.5 per cent of the total if we were to race flat out continually.

Figure 1 illustrates the amount of energy teams typically need to save for each race throughout the season.

Clearly, we need to save energy. There are many approaches to achieving this throughout a lap. The driver can lift and coast, regenerate energy under braking and also sit

in the slipstream of the car in front. For the sake of the example, let's say an energy saving lap consumes 0.95kWh of energy. If we went for an energy saving strategy for the entire race, then $37\text{kWh} / 0.95\text{kWh} = 38.9$ laps, we would have enough energy to complete 38 laps and comfortably finish a 36-lap race.

However, we are likely in last place as we didn't utilise every kWh of energy available.

It is this constant trade-off between energy and lap time that plagues the minds of Formula E engineers. To run the perfect race, they need to establish the fastest way to consume the allocated energy within the available number of laps, with the aim of crossing the line just as they run out of energy.

‘The lap time frontier is essentially the relationship between energy and lap time. It represents the baseline of your efficiency’

Albert Lau, chief engineer at NEOM McLaren Formula E team

Of course, in reality, they need to factor in a little buffer as this is the regulated energy budget, not the real energy of the battery as the driver still needs to get back to the pits.

Calculating consumption

To achieve this, teams calculate an energy target, which is the amount of kWh the driver should consume each lap. In theory, the consumption required to use all the energy for the fastest total race time is simply the allocated energy divided by the total number of laps. So, for our example, $37\text{kWh} / 36 \text{ laps} = 1.02\text{kWh}$. This theoretical target is called the ISO (isometric) energy target, and it assumes ‘free air’, where there

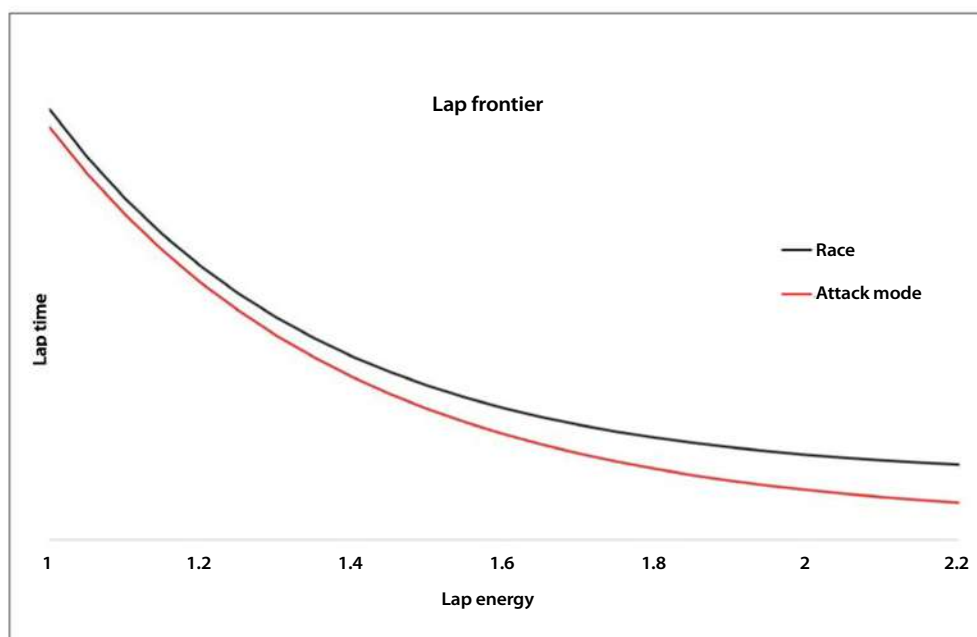


Figure 2: A lap frontier plot shows lap time and energy. Teams use this to see how efficiently they are using their available energy

is only one car on track and the performance of that car remains constant.

Unsurprisingly, it is not that simple. There are 21 other cars on track and the performance of the car varies according to tyre degradation, track evolution and slipstream effects, to name a few factors. Consequently, teams spend a lot of time modelling the effect of all these fluctuating

variables on energy consumption. This is then translated into a frontier plot that helps determine what is the fastest approach.

‘The lap time frontier is essentially the relationship between energy and lap time,’ highlights Albert Lau, chief engineer at NEOM McLaren Formula E team. ‘It represents the baseline of your efficiency. So how well are you using x amount of energy from the RESS

Sitting in the slipstream reduces drag, more so than ever with the Gen3 cars, and is therefore an effective technique employed for saving energy





Circuits with high grip reduce the amount of regeneration possible as there is a smaller difference between the top speed on the straight and the faster corner apex speed



[Rechargeable Energy Storage System] and how that translates to lap time on the track.

'It's clearly non-linear, and we spend a lot of time in the simulator maximising the strategies within the car to ensure we are lower down on that curve where you're gaining more lap time per unit of energy.'

'During the race, you're all over the place on that curve, so it is vital to have good calibrations in the car to guarantee you are using the energy in the most efficient way.'

As expected, the lap frontier shows faster lap times consume more energy. However, its curved nature means there is a sweet spot where drivers can save more energy without sacrificing as much lap time. This is the zone in which all the teams try to operate.

'We create several lap frontier graphs to account for different states of the car,' explains Ash Willoughby, senior energy management engineer at ERT Formula E team.

'The effect of the slipstream is proving to have much more of an influence on energy consumption than in Gen 2'

Ash Willoughby, senior energy management engineer at ERT Formula E team

'For example, we have a lap frontier for 300kW, which is the power we can run during the race, as well as one for 350kW, which we can deploy during the duels in qualifying and attack mode.'

'The effect of the slipstream is proving to have much more of an influence on energy consumption than in Gen2,' continues Willoughby. 'So, we also have lap frontiers to simulate the effect of being in the tow at different points, such as at a 0.5s gap, one second gap, two second gap and so on.'

'Modelling all these different parameters forms a more complex, multi-dimensional frontier plot, but it also helps us understand how much energy we are consuming in different scenarios, and therefore when we need to save energy.'

Saving techniques

The techniques used to save energy throughout a lap are similar to saving fuel. The most effective approach is to lift off the throttle at the end of the straights and coast into braking zones, whilst matching the corner apex speeds of a push lap. This significantly reduces energy consumption for the smallest loss in lap time.

In Formula E, however, teams will try to optimise the precise lift points and communicate this with the driver to maximise saving every possible kWh of energy.

After exiting a corner, the driver will accelerate on the straight and, at a certain point, see coast lights on the steering wheel (similar to gear shift lights) and beeps in their ears to signal the optimum lift point. They then lift off the throttle and brake normally into the corner, regenerating energy back into the battery through the motors in both the front and rear axles.

Another tactic is to stay in the tow of other cars. This reduces the drag on the car and therefore the amount of energy required to overcome this drag for the same speed.

Get a grip

Interestingly, the grip of the circuit can also dictate the amount of energy a car can recuperate. When a circuit has high grip, the drivers can achieve faster corner apex speeds than circuits with low grip. Consequently, the difference between the top speed on the straights and corner apex speed is less on a high-grip circuit than a low-grip one, reducing the opportunity to regenerate.

‘Reducing regen’ means less energy is being used to charge the battery, which can ultimately mean the driver is over consuming relative to their lap energy target,’ explains Willoughby. ‘To manage this, we need to ensure the driver discharges less energy on the straights, to counter the lost charge, so we effectively move the lift point earlier.’

‘The battery derate limits the amount of output power to protect itself, and... over roughly the last two degrees [celsius] of battery temperature, the power can drop from full power down to zero’

Roger Griffiths, team principal at Andretti Formula E

When the car accelerates, the battery discharges energy. When the car brakes, the battery charges. These discharge and charge events are referred to as the duty cycle. Each duty cycle induces high current through the battery and, due to its internal resistance, increases its temperature.

Over the course of an E-prix, this constant discharging and charging of the battery results in high temperatures and, like tyres, batteries operate best within a specific temperature window. Teams therefore have to account for the thermal limitations of the battery when optimising their energy profiles, particularly at races that take place in hotter climates.

If the battery gets too hot or too cold, has a State Of Charge (SOC) that is too low or too high, or too low voltage, it protects itself by derating. This is where the battery effectively limits the amount of power it can discharge and charge, reducing the amount a driver can accelerate or regenerate energy.

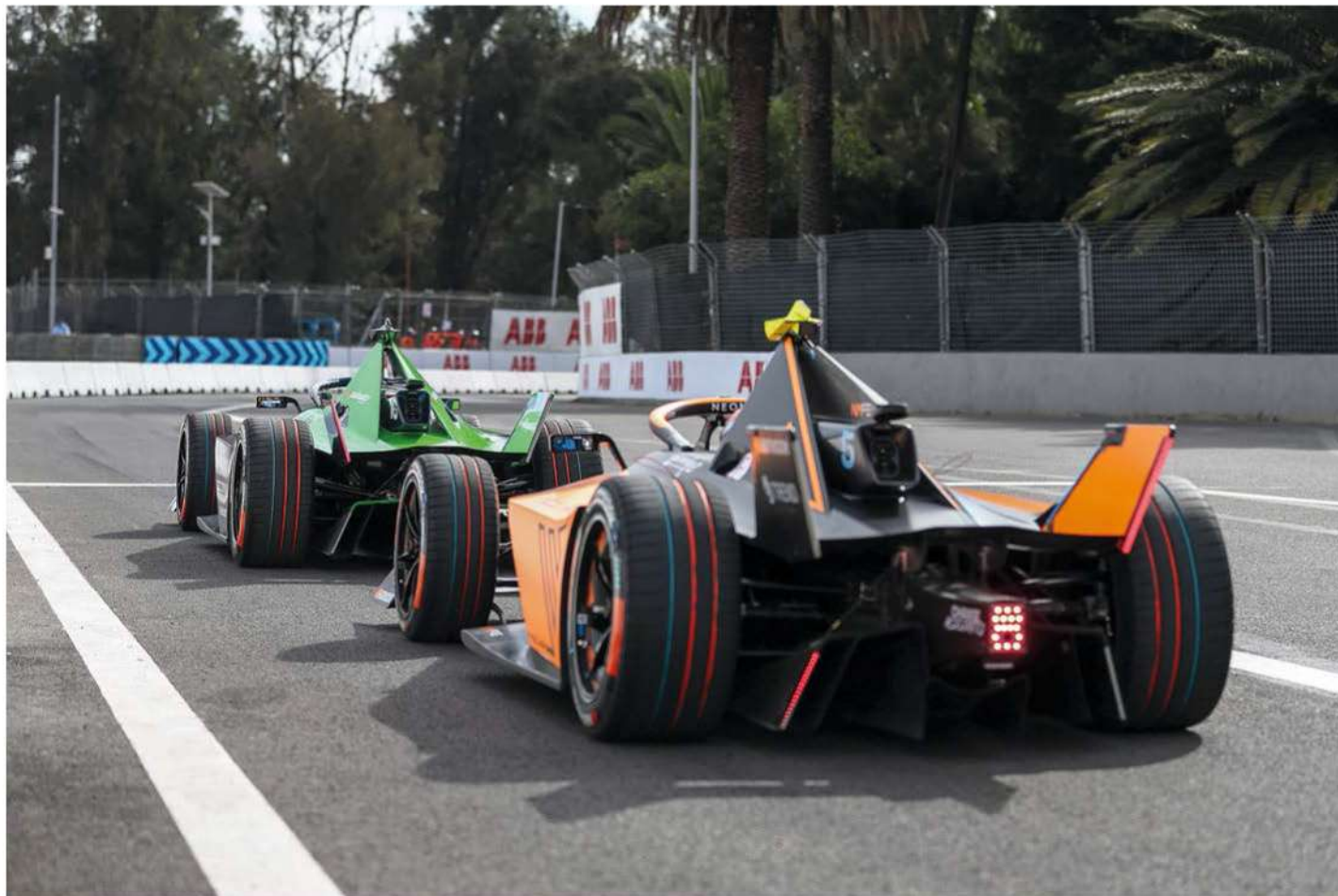
Over consumption

Not only does this make the driver slower on the straights but, by not regenerating as much energy, they will over consume compared to their energy targets. This can ultimately lead to them running out of energy before the end of the race.

‘It’s a similar concept to rising water temperature in an internal combustion engine,’ says Griffiths. ‘When water temperature starts to increase rapidly, you start pulling the ignition to prevent detonation of the engine.’

‘The battery derate limits the amount of output power to protect itself, and this power drops very rapidly within a short temperature delta. Over roughly the last two degrees [celsius] of battery temperature, the power can drop from full power all the way down to zero.’

‘This condition was particularly evident for us in São Paulo, when the battery started to derate and we went from third to fifth in the space of the last two corners.’

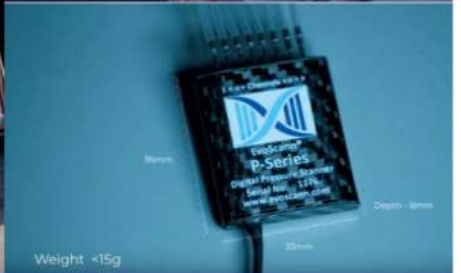


When Formula E began, drivers had to change cars mid-race. Today's Gen3 racers not only have the ability to finish a 45-minute race but are able to regen' more energy than ever, from both axles

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‘So, we have to be particularly mindful at tracks with high ambient conditions because we are then also dealing with the thermal challenges of the battery,’ continues Griffiths. ‘We are constantly modelling battery temperature and predicting whether we have to modify our strategy to compensate for battery thermal issues. Are we going to go into thermal derate or not? Is it advantageous to push into thermal derate or do we want to stay out of it? What can we do from a car settings perspective to manage this?’

‘We try to give the driver multiple tools to adapt the amount of energy they are putting back into the battery.’

There are predominantly two ways to reduce the duty cycle and therefore maintain the battery within its temperature window to avoid derating. The first is to reduce the total energy consumed throughout the race. This ensures the driver completes the race, but they will finish with excess energy.

The second approach is to try and minimise the discharge (acceleration) and

‘We try to give the driver multiple tools to adapt the amount of energy they are putting back into the battery’

Roger Griffiths

Table 1: The evolution in powertrain technology from Gen1 to Gen3			
	Gen1 (2014)	Gen2 (2018)	Gen3 (2022)
Race energy	28kWh	52kWh	38.5kWh
Power output	200kW	250kW	350kW
Maximum regeneration	100kW	250kW	600kW
Top speed	225km/h	280km/h	322km/h

charge (braking) phases of each corner, whilst achieving the same lap energy target. This reduces the duty on the battery and therefore its temperature.

However, both approaches mean driving slower, so teams do everything to manage the battery and avoid excessive derating.

Efficiency evolution

It is not just the teams that spend their days optimising the efficient use of energy, but the championship suppliers, too. Years of pushing the boundaries of battery and motor technology has led to the development of the most efficient racecar on the planet.

Today’s Gen3 racers now achieve drivetrain efficiencies above 95 per cent, and up to 40 per cent of their energy can be recovered during regenerative braking. This is a long way from Gen1 a decade ago, where the race energy of 28kWh, power output of 200kW and maximum regeneration of 100kW meant drivers had to swap cars mid-race to make it to the end.

The 2018 season welcomed a new era with the Gen2 car capable of 52kWh, 250kW power output and 250kW of regen’, allowing

drivers to complete the race with one car. Gen3 arrived in 2022 and its 38.5kWh race energy, 350kW output and 600kW of regen’ makes it 75 per cent more powerful than Gen1, with six times the regen’ capability.

‘Although the push lap time of the Gen3 package wasn’t necessarily the step improvement everyone was hoping for, what people have missed is the massive improvement in efficiency,’ highlights Lau. ‘We’re talking about doing the same number of laps, at relatively similar lap times, in a 45-minute race, but with a RESS that is only 38.5kWh [Gen3] compared to 52kWh [Gen2].

‘This is a massive improvement in efficiency, which has also meant the RESS is now around 100kg lighter.

‘If the Gen3 car had the same chassis and tyres as Gen2, then it would probably have made that step improvement in performance on the weight reduction alone. So, from Gen1 to Gen2, we’ve gone from two cars at 28kWh each to one car at 52kWh, and now Gen3 is one car at 38.5kWh. That massive step at each generation change has predominantly come from the ability to regenerate more energy and, in the case of Gen3, from both axles.’

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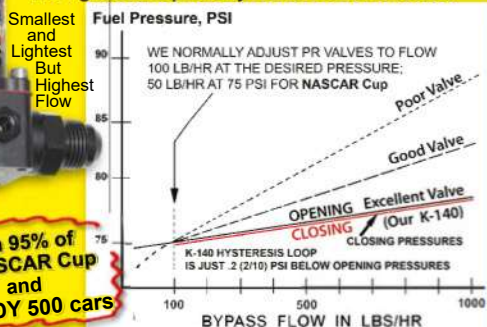
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Synthetic reality

From biofuels and e-Fuel to drop-in fuels and the various colours of Hydrogen, Racecar navigates the current state of the sustainable fuel landscape

By LAWRENCE BUTCHER

What is the future for motorsport powertrains? The answer is not simple and, over the next decade, there will undoubtedly be some false starts and missed deadlines, but all in the name of progress.

Electrification, though it has its place, will not answer every series' needs. Formula E will keep doing its thing, and other series, particularly those that use touring car base models, will probably move that way as well.

For others, electrification is simply not viable. Formula 1 and sportscars, for example, are all likely to keep internal combustion engines until at least the end of the decade, albeit with a hybrid element. Though, as was announced recently, the FIA World Rally Championship has dropped its expensive and problem-prone hybrid system; new powertrain rules beyond the current homologation cycle are still to be confirmed.

That said, racing runs on marketing, particularly for car manufacturers, and it is simply not acceptable, or responsible, to keep burning fossil fuels, no matter how small the quantities are on a global level. This leaves

two viable options: hydrogen (which the ACO is pursuing for endurance racing) and carbon neutral, or at least low carbon, bio or synthetic fuels. It is these latter types of fuel that categories large and small are turning to.

Spot the difference

First up, it is worth breaking down the difference between fuel types, as the terminology is important.

To start, we have biofuels, which covers first and second-generation biofuels. This differentiates between fuels created from food crops, such as corn or sugar cane (first generation) and those created from non-food biomass, which can include fuels made from both bio-waste and non-food crop.

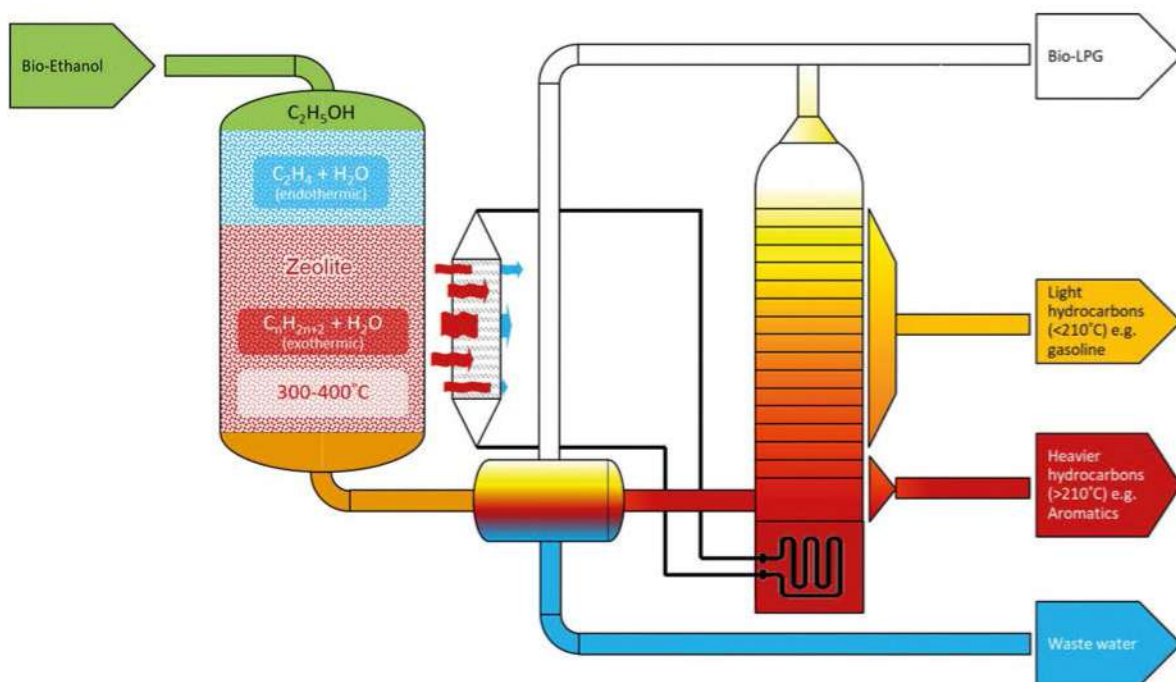
A decade ago, there was investment into the development of algae-based biofuels, referred to as third-generation biofuel, though interest in this source seems to have waned. The most relevant from a motorsport perspective is ethanol, and bioethanol has been blended with fossil fuels for a long time (standard pump fuel in the UK is now either E10 or E5, denoting the ethanol content).

However, blending at too high a ratio can result in a host of issues for regular fuel systems, unless they are specifically designed to handle alcohol fuels.

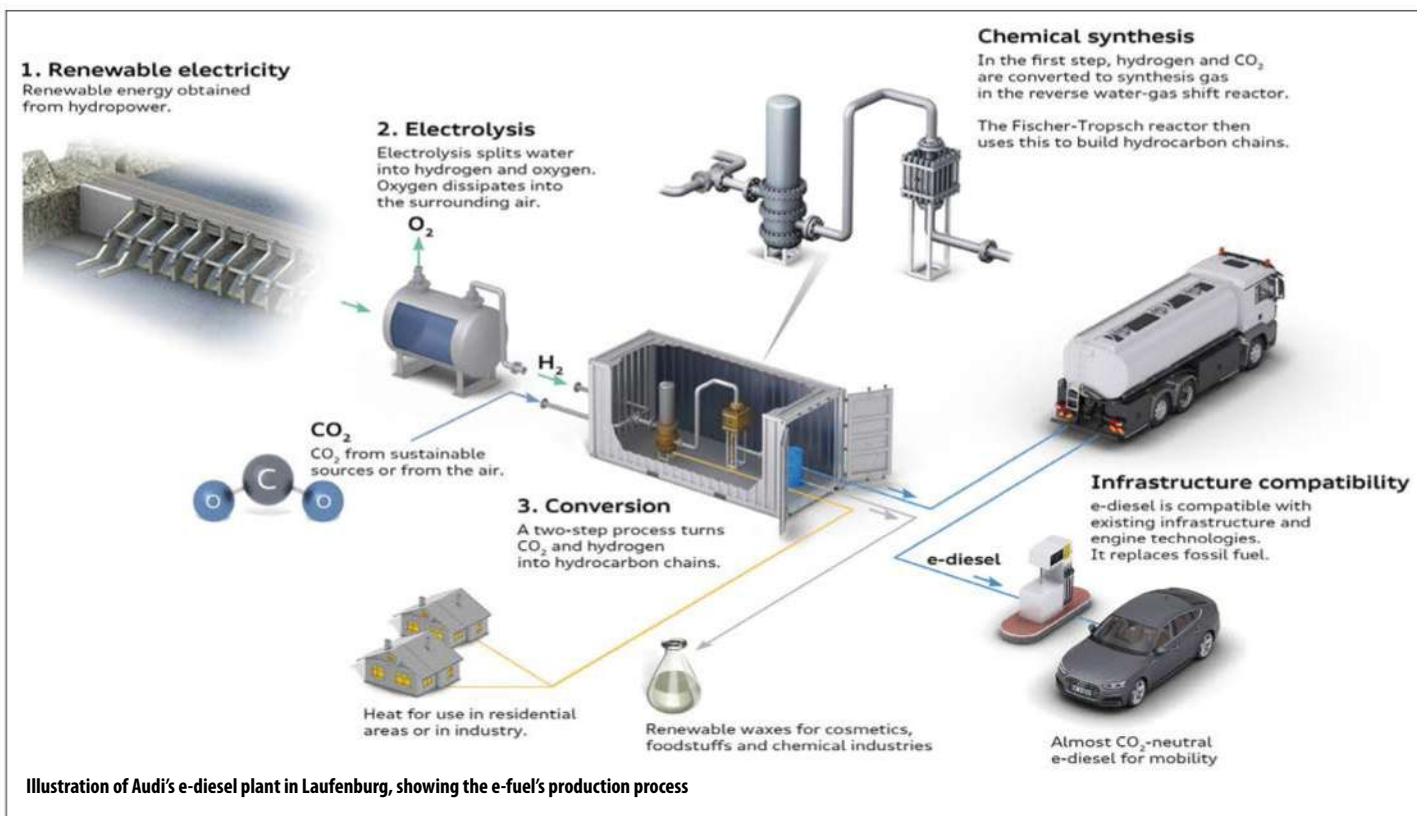
Fortunately, there are now advanced biofuels, which take this pure bioethanol and process it further, creating something much closer to traditional petrol (gasoline). It is this type of fuel that is being used in the WRC and WEC (both 100 per cent biofuelled).

F1, meanwhile, is using an E10 blend but should move to 100 per cent biofuel by 2026 when its new power unit regulations come into play. The Formula 2 championship is at something of a halfway house, with a 55 per cent biofuel blend.

To create true 'drop-in' fuels for racing, bioethanol needs to be further processed to create bio-gasoline, which can then be blended with pure ethanol in the same way that traditional petrol is. This can be done in a variety of ways, creating long chain hydrocarbons that can be refined and blended in the same way as traditional fuel. Lighter portions are used to make petrol, the heavier 'cuts' are used for other chemical production.



Schematic of the ethanol-petrol (gasoline) conversion process



Then one comes to fully synthetic, or e-fuels. These do not use any biomass in their production and instead rely on the combining of hydrogen and carbon.

e-fuels

Synthetic fuels are not new; they have been around since the early to mid-20th century. During the Second World War, around half of Germany's fuel was created in synthetic fuel plants, either from coal using the Bergius process, where powdered coal is mixed with tar and iron oxide and then heated at high pressure with hydrogen, or the Fischer-Tropsch process using hydrogen and carbon monoxide. We will return to the issues these presented, particularly in aviation fuel, later.

Clearly, the use of coal isn't going to cut it in the sustainability stakes, but the creation of fuel from hydrogen and carbon dioxide could have legs. The key is renewable energy and carbon capture.

Hydrogen is not found on its own very often in nature (though this maybe a misrepresentation; see sidebar on p73), so it must be processed from other compounds.

The most common means of hydrogen production is through the process of steam re-forming natural gas or methane. This sees the hydrogen containing gas reacted with steam at high temperatures (700-1000degC) under pressure (3-25bar), with a catalyst to produce hydrogen, carbon monoxide and carbon dioxide.

A process called a water gas shift reaction then uses another catalyst to react the steam and carbon monoxide, producing both CO₂ and more hydrogen. The CO₂, and any other impurities, are then removed, leaving pure hydrogen.

The problem currently is that this process is both energy intensive and uses a fossil fuel – natural gas – hence hydrogen produced by this means is termed 'grey hydrogen'.

A more sustainable version of steam re-forming sees the produced carbon dioxide get captured, resulting in blue hydrogen.

However, the ideal is so-called green hydrogen, which is produced from water via electrolysis. The important part being the electrolysis is powered by renewable energy.



Race series around the world are taking the fuel debate seriously. The ACO is backing hydrogen for endurance racing, while others are exploring the possibilities offered by bio and synthetic fuels

Karl Dums, team lead at Porsche in the development of synthetic fuels, acknowledges that the only way the company will meet its decarbonisation goals is to factor existing vehicles into the plan



If this hydrogen is then used to create synthetic fuels – provided the process is completed using renewable energy and the carbon is captured from the atmosphere – the end result is a truly carbon neutral fuel.

The Fischer-Tropsch process is a series of chemical reactions that convert a mixture of hydrogen and carbon monoxide (called syngas) into liquid hydrocarbons. With each reaction, different compounds are created, until the desired compounds are arrived at for use in fuels and other applications.

Much like the refinement of crude oil, Fischer-Tropsch produces a range of end products that can be categorised by their molecular chain length – short, medium and long – with the middle of these being the ideal starting point for fuel production.

Efficiency argument

The benefits of biofuels and synthetic fuels are many, not least they allow for the use of existing and refined powertrain technologies and infrastructure with a reduced, or net zero, impact on carbon emissions.

In the case of e-fuels, they can represent an effective means of transporting energy from areas where renewable energy may be plentiful but demand for energy is low (there is a good reason Porsche's pilot plant is in a windswept part of Chile, for example).

While this energy could be used to produce hydrogen, which is then shipped, the transporting of hydrogen is considerably more complicated than liquid fuel.

There are some valid arguments against e-fuels being the future path for transport, most of which centre around the efficiency of their production

However, there are some valid arguments against e-fuels being the future path for transport, most of which centre around the efficiency of their production. There are, of course, also the standard tropes about non-CO₂ tailpipe emissions, but modern combustion engines and their after-treatment systems make these almost irrelevant.

The efficiency argument holds water to an extent. The electrolysis process to produce hydrogen via electrolysis is an energy intensive one and there are losses. The current efficiency is in the region of 70-80 per cent, though the latest developments in PEM (proton exchange membrane) electrolyzers should see this figure edge closer to 90 per cent by the end of the decade.

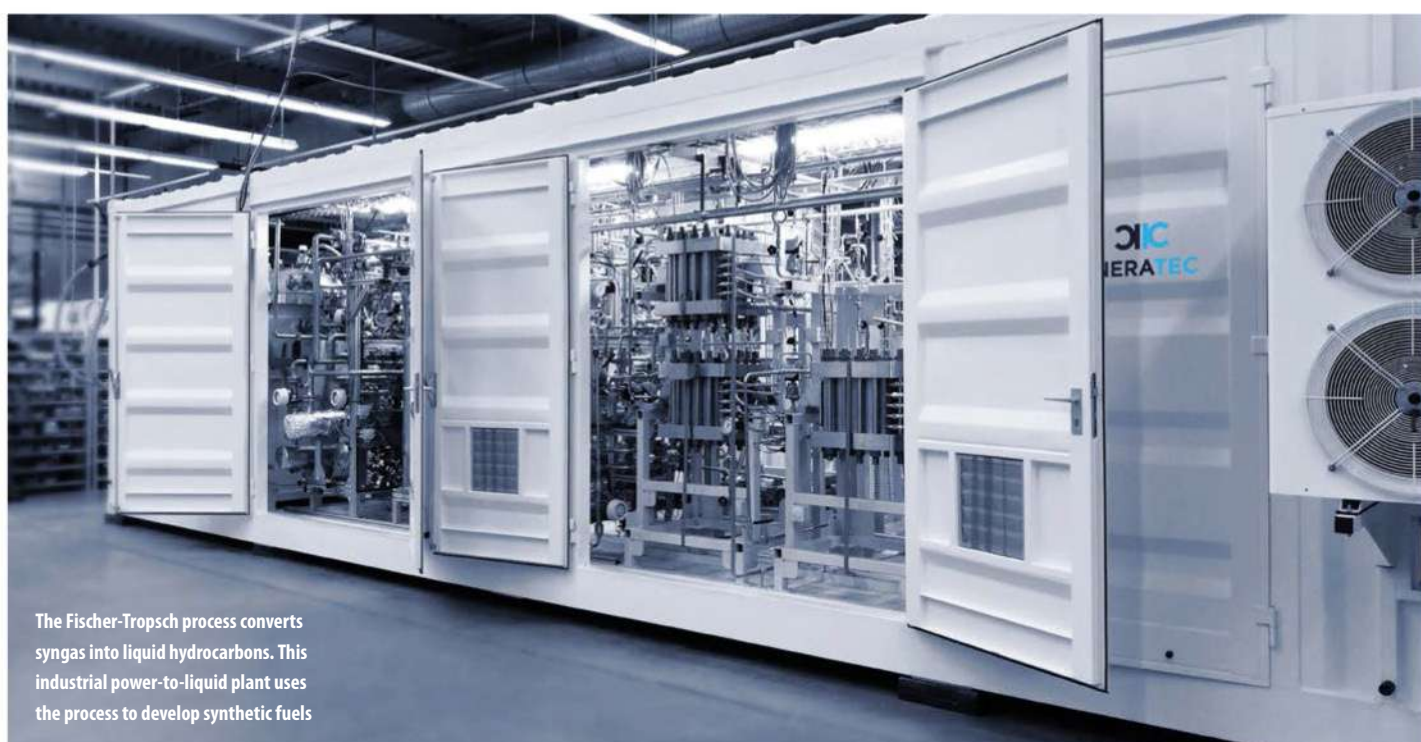
There are also the losses in the e-fuel production process itself, not to mention the losses experienced when the fuel is burnt in an ICE. While current F1 power units may



Porsche chose a barren area of Chile, with an abundant renewable energy source, for the site of its synthetic fuel development plant



Where the switch to all electric demands the disposal of millions of existing ICE vehicles, bio and synthetic fuels can use existing technologies and infrastructure



exceed 50 per cent thermal efficiency, even the latest production car engines operate in the 35-40 per cent bracket, though this will inevitably increase.

BEVs, meanwhile, manage to net around 70 per cent well-to-wheel efficiency. The crux being that they cannot compete with e-fuels in terms of energy density and, more importantly, renewable energy generation fluctuates. If there is an excess of energy, it either needs to be stored in batteries or, preferably, used to produce renewable fuels.

There are also cost hurdles in the way of widespread use of bio and synthetic fuels. Currently, they are markedly more expensive than traditional petrol, though this is less of a concern in racing. However, if production is scaled and efficiencies along the production process realised, their proponents claim they should come into line with traditional fuels by the end of the decade.

Engine challenges

The biofuel and synthetic fuel landscape is constantly evolving but, looking at the current state of play, there are still notable challenges for motorsport, even with so-called 'drop-in' fuels.

As various FIA championships have moved towards their use, those tasked with building and running engines have not had a straightforward task. One WRC technical director commented, 'The fuel was meant to be drop-in, it's not. We have all had things going on in the background because the fuel is... [insert diplomatic pause] difficult to use.'

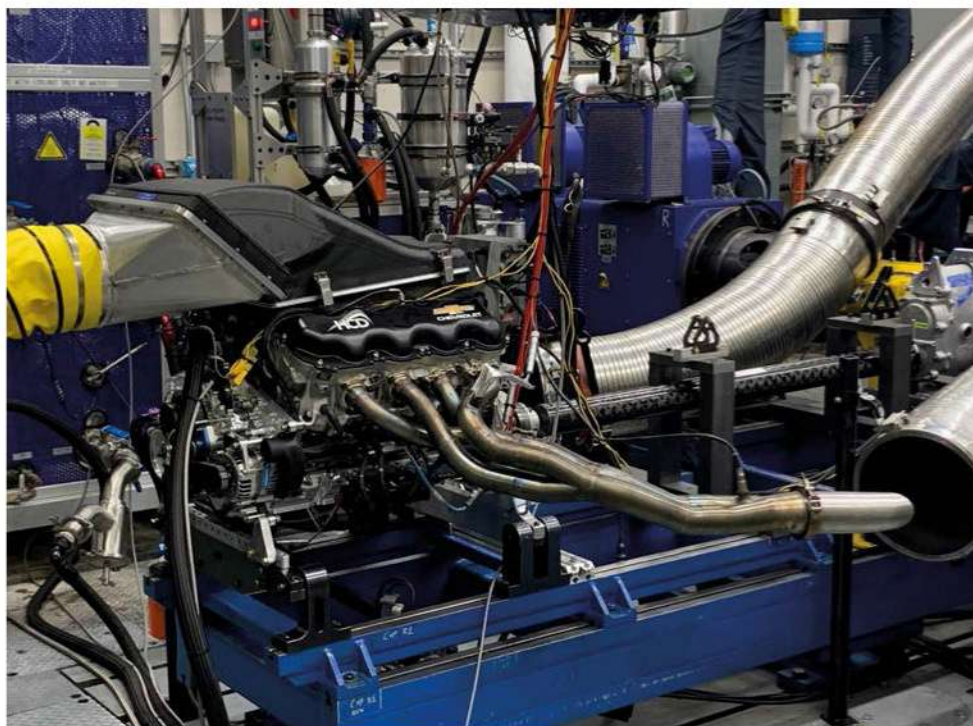
Most of these problems centre around the cuts of fuel and additive packages that are blended to create the finished product. One engine developer in an FIA championship explained it as such:

'Whereas your traditional racing fuel is made from fractions from the middle of the range – the Goldilocks mix if you like – not too heavy and not too light, the current crop of fuels tend to have very light and very heavy components, blended to achieve the result.'

'Unfortunately, the stability of this mix is not assured, not least because lighter parts tend to evaporate, leaving only the heavy parts.'

'In an old school, naturally aspirated engine, with either port injection or carburettors, this is not such an issue, but with the refined, direct injection systems found in WEC and the WRC, coupled with turbocharging, it plays havoc with the precise spray patterns and knock resistance.'

Fuel dilution of the lubricating oil is another problem being experienced. Due to the high heat of evaporation of bioethanol, unburned fuel is more likely to settle on the combustion chamber walls and then be scraped down into the crankcase, to a far greater extent than regular petrol, which evaporates at lower temperature.



While often touted as 'drop-in' fuels, as General Motors engineers discovered during the NASCAR Garage 56 project at Le Mans in 2023, the use of biofuels can lead to other issues, such as rapidly increased engine wear



Audi took an innovative path with the development of its RS Q e-tron Dakar racer, which is battery electric but also has a TFSI ICE as part of its energy conversion system to charge the battery on the go

Compounding the issue of dilution is the fact that bioethanol is immiscible with oil, so emulsions form within the oil, with potentially catastrophic results.

This was highlighted by ECR Engines, which built the Garage 56 NASCAR engine that ran at last year's 24 Hours of Le Mans. During development of the car's pushrod V8, the team ran into unexpected valvetrain wear issues that were quickly identified as being caused by dilution of the oil by Total's spec biofuel, which is supplied to all Le Mans cars.

ECR solved the issues with modifications to the pushrod and rockers, but its experience

shows that even the more advanced fuels available are not yet quite 'drop-in'.

The issue of dilution can be addressed, for example, by creating the conditions for higher crankcase temperatures to help the fuel evaporate, though that can also lead to a situation where the heavier constituents are left behind, potentially increasing oil viscosity.

Old news

This is not a new development, as noted earlier. Germany experienced various problems with its synthetic, high-performance aviation fuels in the Second World War.



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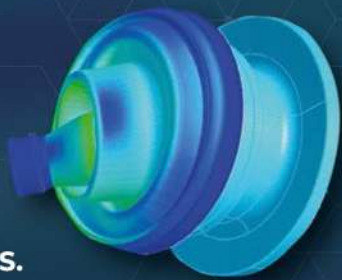
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As Callum Douglas' excellent tome on WW2 aircraft engine development, *The Secret Horsepower Race, Western Front Fighter Engine Development* details, deployment of the Daimler-Benz DB 601 engine was hobbled by the fact it was designed to run on a particular spec of fuel, designated CV2B.

Unfortunately, this blend was impractical to produce in large quantities. The more readily available C3 fuel was therefore substituted, but problems with bearing failures began to arise after 200-300 hours of running. The culprit was the fuel's high boiling point, 175degC compared to C2's 125degC, which led to dilution of the oil.

The solution was to run higher engine temperatures, but this necessitated an entire re-design of the cooling and fuel system. Compounding the problem, the C2 fuel still available had been in storage too long, and the evaporation of vital elements destroyed its knock performance, rendering it unusable.

Ultimately, none of these challenges are insurmountable, and many are the result of overzealous regulators writing cheques their chosen fuels can't cash.

Untapped resource

Currently, the future of synthetic fuels hinges around a prevalence of low, or carbon neutral, energy, be that from wind, solar or nuclear, in order to power electrolysis plants. However, there is potentially a vast, untapped resource of hydrogen that is just starting to garner interest. This is naturally occurring, or so-called 'white' hydrogen.

This is hydrogen sourced from underground reservoirs in much the same way as oil or natural gas. Until recently, no one had considered the possibility of such deposits, thanks to hydrogen's flighty nature and ability to escape even the tightest containment. This was because no one was looking in the right place, or looking at all. But the clues were there.

In 1987, well diggers in a small village in Mali, west Africa, drilled a bore hole. It didn't yield water, but they hit a gas pocket which caught fire, much to the consternation of the villagers. The hole was capped and sealed until 2012 when a petroleum company, at the request of Malian businessman, Aliou Diallo, re-visited the site and ascertained the escaping gas was 98 per cent pure hydrogen. That hydrogen well has been providing the village with power ever since.

Fast forward a decade and, with demand for hydrogen set to increase, hydrogen exploration projects are popping up across the globe. A study by the US Geological Survey suggests that there could be trillions of tons of sub-surface hydrogen, albeit much of it currently inaccessible. However, even if only a small percentage of the reserves are economically viable, their discovery and exploitation could upend the calculus that currently makes hydrogen a desirable, but expensive, foundation for synthetic fuels, or as a fuel in its own right.



Toyota is investing heavily in testing and development of hydrogen as a fuel source. This is its GR Corolla H2 Concept

Modification to hardware and calibration can overcome the vast majority of them but, at least in the WRC, engine builders only found this out at a late stage in the development cycle, with modification to injectors and other parts having to be made under the token system that rallying uses, which they would much rather have spent on performance-related developments.

Of course, the developers of renewable fuels are aware of their shortcomings and developments are underway to improve their properties further. By the end of the decade,

hopefully, there should be a true drop-in alternative to petrol readily available.

Parallel to the development of sustainable fuels, there is also a move to making other, currently fossil-based, fluids more sustainable, including lubricating oils.

Net positive

Despite some of their disadvantages compared to traditional racing fuels, on balance, increased adoption of bio and synthetic fuels in racing is a net positive. Not only will manufacturers involved in the sport be able to assuage environmental concerns; further down the pecking order, racers will still be able to compete, even as legislation puts ever greater pressure on ICE vehicles.

This is an important consideration. As more and more countries and regions enact clean air policies, being able to present a sustainable argument for the exemption of racing is vital. 

None of these challenges are insurmountable, and many are the result of overzealous regulators writing cheques their chosen fuels can't cash



Racing will continue to play a vital role in the development of fuels of the future, whatever they may turn out to be



Damping in the wild

The Damper Workbook applied to a 900bhp beast of a case study

By **DANNY NOWLAN**



Tomohiko 'Under' Suzuki and his radical Scorch Racing Silvia S15 compete in the Pro class of Time Attack and is the subject of this month's application of knowledge article

One of the most inherent beliefs in English-speaking culture is that one can see further if one has 'stood on the shoulder of giants'. This article is proof positive of this.

Yes, myself and ChassisSim have carved a reputation for being damper masters, but the only reason we could do this is because of people like Kurt Roehrig. The founder of Roehrig Engineering was a key pioneer in popularising the damper dyno. Very sadly, Roehrig has been diagnosed with a degenerative terminal illness but, if you want to appreciate his legacy, this month's article would not be possible without his good work.

One of the most popular articles I have ever written for *Racecar*, and one of the most downloaded items on the ChassisSim website, is the Damper Workbook.

Not only does it show you that this is a hot button topic, but also that there is a lack of genuine information on this important element of racecar tuning.

One of the traps I see people regularly fall into when working on racecar damping is the temptation to over complicate things when they don't need to. What we'll be doing in this article is applying the knowledge we have learned, and showing how simulation tools enter the equation, using a car I once worked on.

The car in question is the Scorch Racing Nissan Silvia S15 Time Attack car, shown above, as raced by Tomohiko 'Under' Suzuki in the Pro class at World Time Attack challenge held at Sydney Motorsport Park.

This car is a monster. We're talking 900bhp and CLA numbers well north of seven.

Seriously, if you put racing slicks on this thing, over the course of a lap it would make most circuit cars look rather modest.

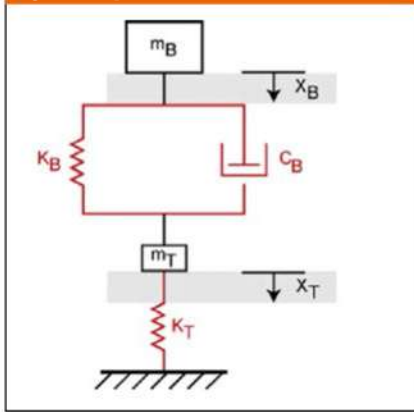
The other joker in the pack here is the tyres it uses are a halfway house between a performance road tyre and a racing slick. Consequently, this offers a great case study of just how effective this approach can be.

The other thing to consider before we begin is the way the damping curves were deduced on this car. Basic high school maths got us into the ballpark, and then the simulation software took us the rest of the way. No magic wand was waved. *This* is how you use simulation properly.

So, let's get cracking with the application. Your start point, as always, is the quarter car model. To refresh everyone's memory, this is illustrated in **Figure 2**.

One of the traps I see people regularly falling into when working on racecar damping is the temptation to over complicate things, when they don't need to

Fig 2: the quarter car model



The quarter car model is the most basic building block of racecar damper analysis. Yes, it is simple and, in order to use it, you cut corners by assuming the body rate is much lower than the tyre spring rate. This is an assumption that leaves a lot to be desired for high-downforce cars because of the high spring rates you need to hold the car up.

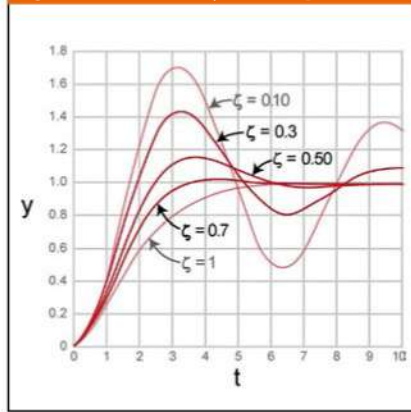
However, the power of the quarter car model is that it is simple and, when used intelligently, it gets you a fair way down the road quite easily. I've done the derivation of this to death in previous articles, but the following two equations need to be committed to memory.

$$\omega_0 = \sqrt{\frac{K_B}{m_B}} \quad (1)$$

$$C_B = 2 \cdot \omega_0 \cdot m_B \cdot \zeta$$

$$\zeta = \frac{C_B}{2 \cdot \omega_0 \cdot m_B} \quad (2)$$

Fig 3: Second order system response



Where,

- ω_0 = natural frequency in rad/s
- K_B = Spring rate of the quarter car in N/m
- m_B = Quarter car mass in kg
- ζ = Damping ratio
- C_B = Damping rate in N/m/s

Right away, there are a couple of traps for young players here. Firstly, all the wheel and damping rates are wheel rates. We'll talk about what they look like at the damper shortly. Also, work this in strict SI / metric units. I know this will annoy some of our American readers, but you'll get over it.

Theoretically incorrect

Now, there is one thing to note about what we have done with the quarter car vehicle model. The equations here effectively treat the tyre spring as infinite, and approximate the car as a simple spring damper unit at the sprung mass. While this is not theoretically correct, for road cars it's a very good approximation and for a high-downforce racecar it gets you a decent start.

Also, because this is so numerically simple, it gives you a quantitative basis to start talking about your damping. And, as we are about to find out, this can be brutally effective. It also takes you into a much larger and more precise world.

The next step in this process is to understand what you want the damping ratio to do. To do this, we need to consider a typical second order system response. An example of this is shown in **figure 3**.

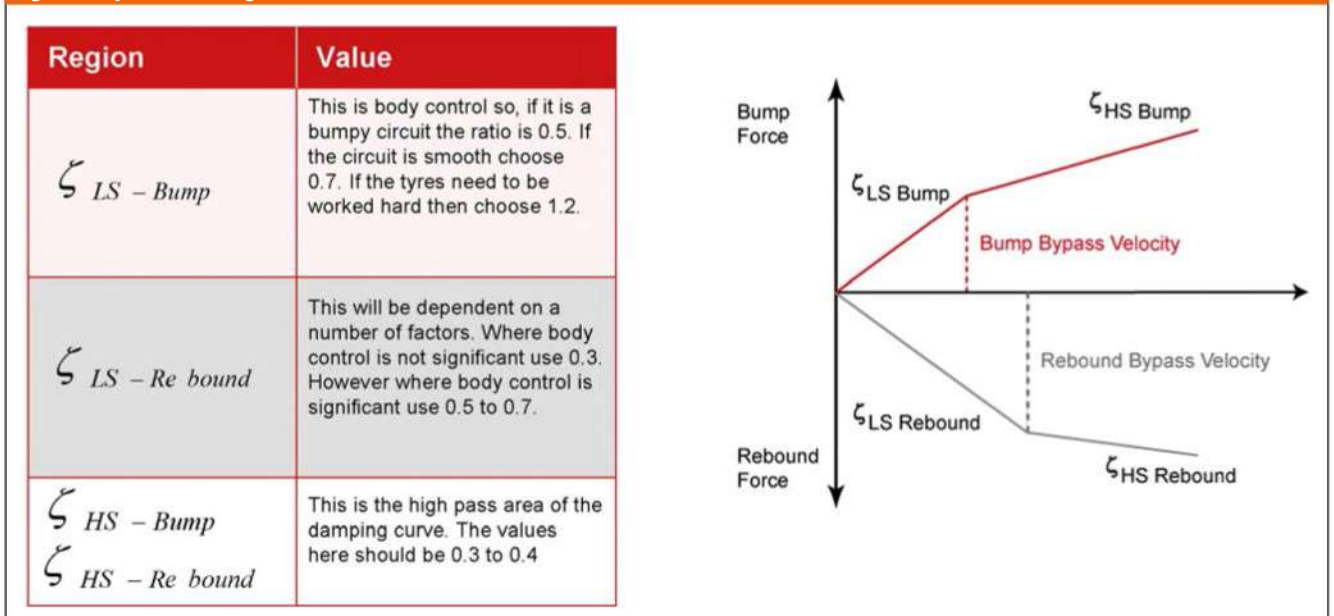
The reason the second order damping response is so important here is because it closely resembles the quarter car model. As we can see from **figure 3**, when the damping ratios are quite low (at about 0.3-0.4) we have a lot of oscillatory behaviour. Not great for body control but really good for riding bumps. However, with damping ratios greater than 0.5, the damping response is quite good. Bad for bumps this time, but great for body control.

If you can understand these two principles, you are well on your way to specifying a damper curve. Incidentally, for any of you reading this who have a problem with the curve shown in **figure 3**, it comes from D'Azzo and Houpis, *Linear Systems Control Analysis and Design*. This is the go-to textbook for aerospace and electrical engineers designing flight controls.

These guiding principles about bumps, body control and damping ratios segue neatly into the next stage of the process, the damper selection guide. This is presented in **figure 4**.

For low-speed damping, body control is paramount. For mechanical cars, we are talking damping ratios of 0.7, and for high-downforce cars we are talking damping ratios of at least one. My hard limit here is 1.4 but you get the idea.

Fig 4: Damper selection guide



In low-speed rebound for mechanical cars you are talking damping ratios of 0.4-0.5, while for high-downforce cars you are looking at damping ratios of 0.7. There is an outlier on this, but I'll discuss that at length in a future article.

Guiding principle

So, with this as our guiding principle, let's work through an example of how you figure out the damping rates and put together a damper curve. To kick off, let's consider the quarter car parameters shown in **table 1**.

Table 1: Quarter car parameters

Parameters	Value
Quarter car mass	250kg
Motion ratio	0.8
Base spring rate at damper	300N/mm

Now we have this, we need to figure out the natural frequency. This is shown by **equation 3** below.

$$\begin{aligned}\omega &= \sqrt{\frac{K}{m}} \\ &= \sqrt{\frac{MR \cdot MR \cdot K}{m}} \\ &= \sqrt{\frac{0.8 \cdot 0.8 \cdot 300 \times 10^3}{250}} \\ &= 27.7 \text{ rad/s} = 4.41 \text{ Hz}\end{aligned}\quad (3)$$

Now that we have that figured out, we need to work out the base damping rate. This is called C_{BR} and is shown by **equation 4**.

$$\begin{aligned}C_{BR} &= 2 \cdot m \cdot \omega_0 \\ &= 2 \cdot 250 \cdot 27.7 \\ &= 13856.4 \text{ N/m/s}\end{aligned}\quad (4)$$

Once we have the base damping rate, we can choose the actual damping we need. For the low-speed rates we'll choose a damping ratio of one, and for the high speed we'll choose a damping ratio of 0.5. With those in mind, see **equations 5** and **6**.

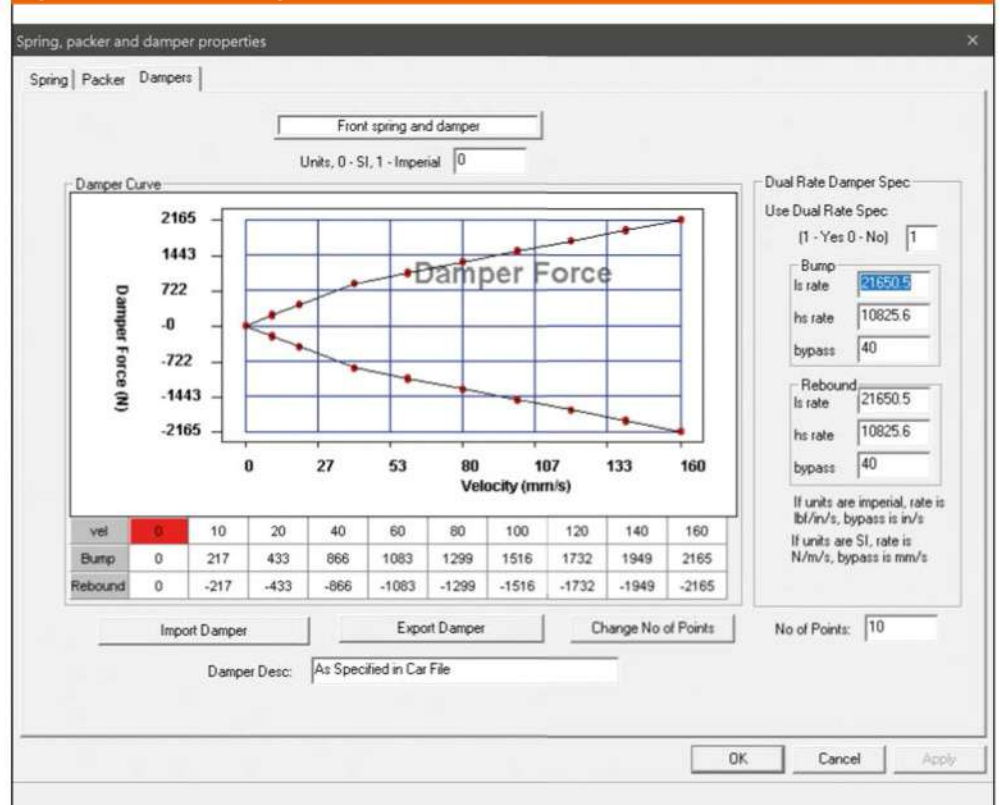
$$\begin{aligned}C_{LS} &= C_{BR} \cdot \zeta_{LS} \\ &= 13856.4 \cdot 1 \\ &= 13856.4 \text{ N/m/s}\end{aligned}\quad (5)$$

$$\begin{aligned}C_{HS} &= C_{BR} \cdot \zeta_{HS} \\ &= 13856.4 \cdot 0.5 \\ &= 6928.2 \text{ N/m/s}\end{aligned}\quad (6)$$

Here, C_{LS} and C_{HS} are the low and high-speed damping rates respectively.

The last step is obtaining damper rates at the damper. To do this, divide by the motion ratio squared (assuming the motion ratio is damper movement / wheel movement)

Fig 5: The result of entering a dual rate model in ChassisSim



Crunching the numbers, we see that shown by **equations 7** and **8**.

$$\begin{aligned}C_{D_{LS}} &= \frac{C_{LS}}{MR^2} \\ &= \frac{13856.4}{0.8^2} \\ &= 21650.6 \text{ N/m/s}\end{aligned}\quad (7)$$

$$\begin{aligned}C_{D_{HS}} &= \frac{C_{HS}}{MR^2} \\ &= \frac{6928.2}{0.8^2} \\ &= 10825.2 \text{ N/m/s}\end{aligned}\quad (??)$$

At this stage of the game, you might be thinking: this is all great, but how do we get a damper curve?

Here's where the dual rate model in ChassisSim is about to become your best friend. If you have ChassisSim, all you have to do is click on the damper tab, choose the dual rate model, fill in the numbers and, when you press OK, you'll have something like that shown by **figure 5**.

When this process is done, you'll have a base damper curve, but we're not quite there yet. There is still work to do.

The next step is to use the ChassisSim shaker rig toolbox. Usually, for a mechanical car, I'll focus on minimising contact patch load variation and then tune the frequency response. For a high-downforce car, the frequency response and, in particular, minimising the cross pitch mode becomes

dominant because controlling the aero platform is your number one priority.

However, when this process was applied to Under Suzuki's car, a number of key challenges were faced. Firstly, due to the nature of the tyres, you couldn't muscle it out with big main spring rates. That was a non-starter. Significant support had to come from the third spring and, when you do this, you have to factor this into your natural frequency and damper calculations we showed earlier.

Tricky by nature

The other thing that made this particular job very tricky was the high aero load. That, together with the nature of the tyres, meant both aero response and contact patch load variation became equally important.

What all this translated into was a lot of simulation work. The end result of this is shown in **figure 6**.

For a high-downforce car, the frequency response and, in particular, minimising the cross pitch mode becomes dominant because controlling the aero platform is your number one priority

Fig 6: End result of the shaker rig analysis work

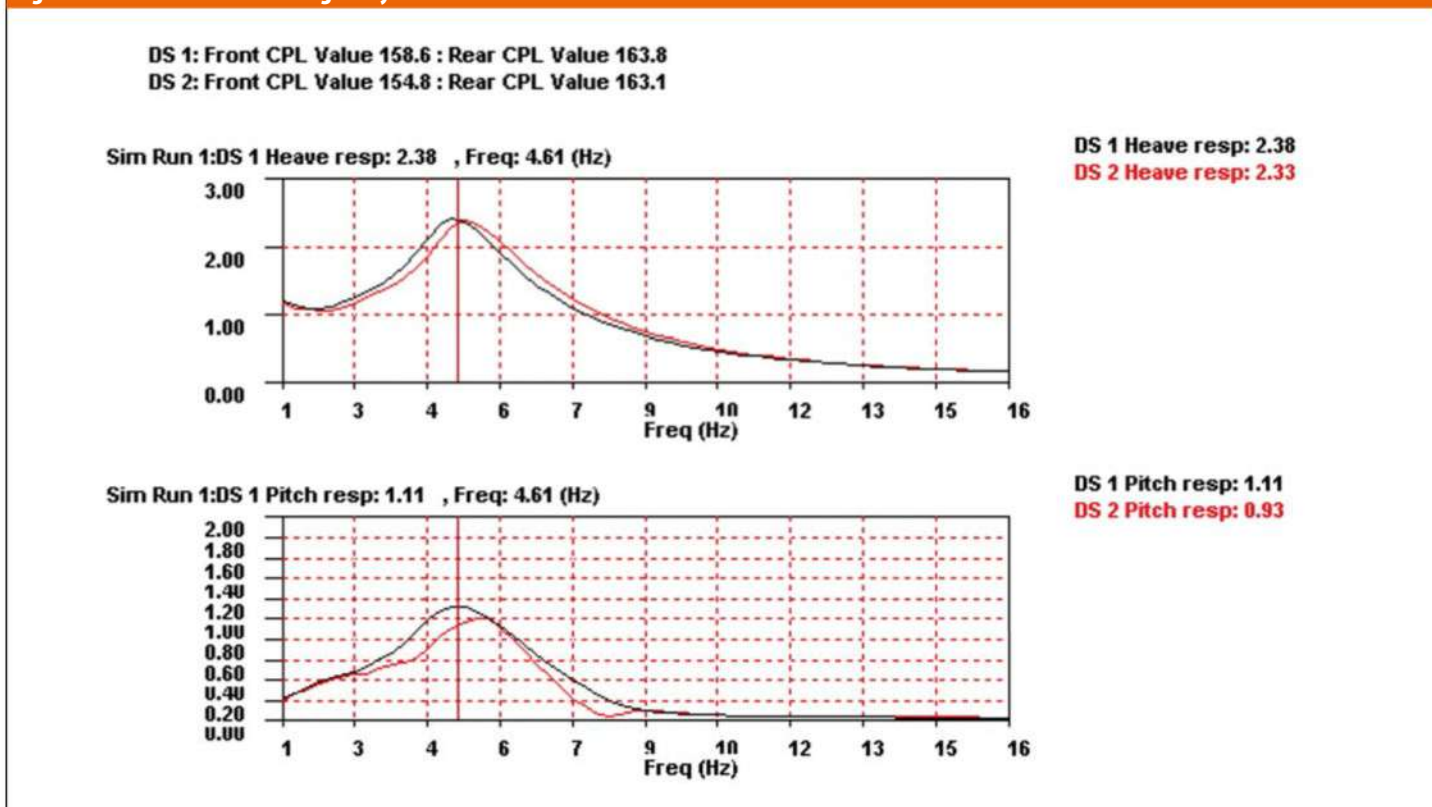
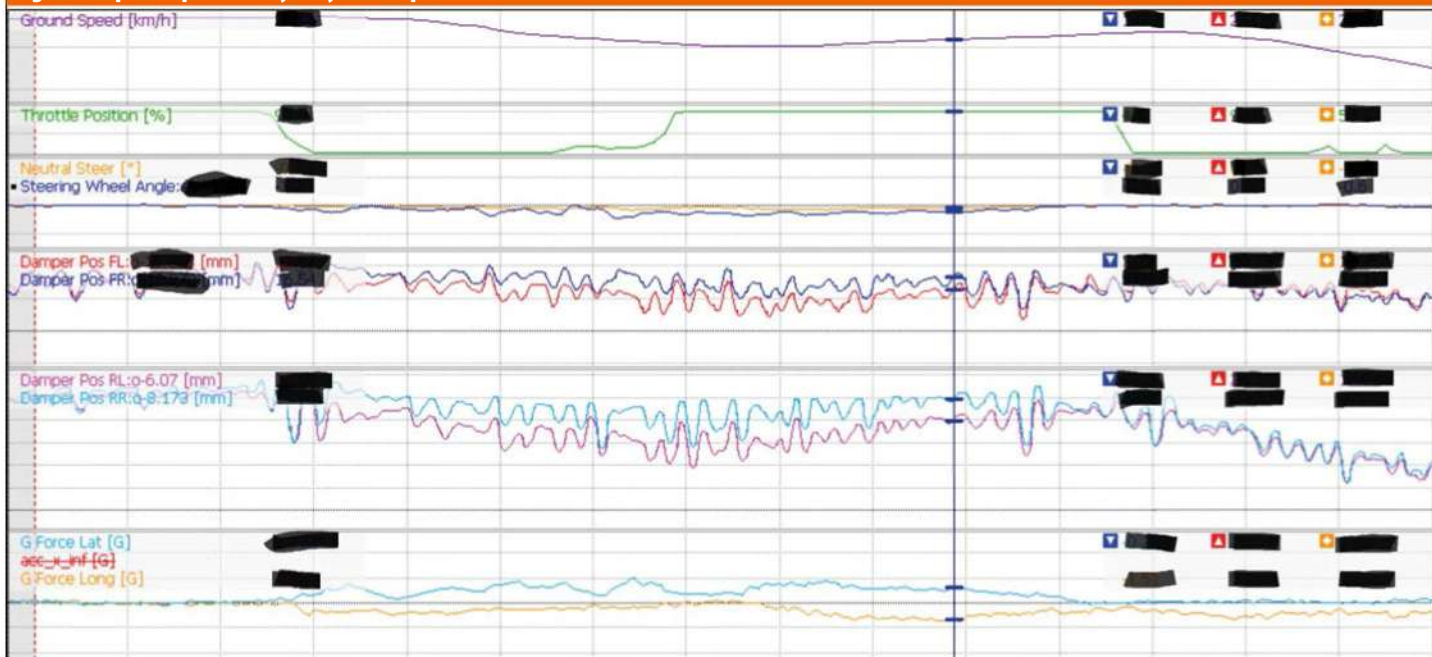


Fig 7: Damper response at Sydney Motorsport Park



On the trace, initial damper spec is shown in black and final damper design in red. As can be seen, the contact patch load variation has dropped by 4kg at the front and 0.8kg at the rear, while the cross pitch mode response has dropped by nearly 20 per cent. If you see results like this, you put them on the car! The net result of which is shown in **figure 7**.

Due to confidentiality, scalings have been blanked out, but the traces are speed, throttle, steer, front dampers and rear dampers, followed by longitudinal and lateral *g*.

In the low-speed section, car response is excellent, but there were still issues at high speed, which were resolved by going up in the high-speed damping.

The important part was the process translated into improved car performance. Even on tyres that were over 12 laps old, Suzuki recorded a lap time of 1m 22.3s at Sydney Motorsport Park. Even more significant here is that Pro class cars in Time Attack rarely get more than three laps out of a set of tyres, so this was unprecedented.

Unfortunately, an accident after that put the car out of commission, so we were unable to get a true measure of its new pace.

In closing, what we have shown here is a real-life case study of how to tune dampers. While this method is not perfect, it is simple, practical and gives a feel for the numbers.

Combine this with simulation and use it as a calculator (as opposed to a magic wand) and the results will take care of themselves. The improved pace of Suzuki's Time Attack car is proof positive of this. **R**

IN BRIEF

Red Bull Advanced Technologies has partnered with Austrian company, **AVL**, to produce what the companies call the 'next generation of ultra-high-power density fuel cell technology.' The idea is to produce high-power, low-weight battery packs that will be suitable for high-performance automotive, motorsport and aviation.

McLaren has parted ways with former Ferrari aero specialist, **David Sanchez**, after only a few months and the first few races of the 2024 FIA Formula 1 World Championship. Sanchez has vacated his position as technical director, car concept and performance, which has triggered a series of updates across the department. **Rob Marshall**, signed from Red Bull, will assume the role of chief designer, **Neil Houldey** is the new technical director of engineering, while **Peter Prodromou** continues in his role as technical director of aerodynamics.

Hyundai has confirmed it will return to the Pikes Peak International Hillclimb this year to chase the Electric Production SUV/Crossover record with its IONIQ 5N cars. The cars will feature increased safety with racing seats, belts, fire suppression system and a roll cage, but will otherwise be standard, without a rear seat.

Formula 1 has confirmed a 25-race schedule for 2025, starting in Australia on 16 March and ending in Abu Dhabi on 7 December. The FIA says the new programme has created 'a better geographical flow of races.'

Lubricant company, **Motul**, has reached an agreement to be title sponsor of the Castle Combe circuit, and of the German Action Day car show in August. Changes to the track include re-naming the home for hacks as the Motul Media Centre.

The next **Mercedes-AMG GT3** car, which was signed off late last year and will be introduced at the earliest in 2026, will not be built by long-term Mercedes partner team HWA, which has served in that position since 2011. Rumours connect Reiter Engineering with the project.

Full steam ahead for H24



The ACO's hydrogen-powered H24 (shown) will be demonstrated at the Spa WEC race, together with Alpine's hydrogen ICE-powered Alpenglow

The ACO's bid to introduce hydrogen technology will take a step forward ahead of this year's running of the 24 Hours of Le Mans when two cars featuring different technologies will complete demonstration laps ahead of the 6 Hours of Spa in May.

The H24, which has been developed through the ACO and was demonstrated at Spa in 2023,

will be joined by Alpine's Alpenglow, which is powered by a combustion engine using hydrogen as fuel.

The ACO originally planned to run only a fuel cell in its top-tier class, but combustion engine technology is evolving so quickly that the organisation decided to adapt its regulations to reflect that. The current plan is to introduce a

hydrogen class at Le Mans in 2027, and the ACO says it has a number of manufacturers sitting at the table to establish the regulations. They are known to include Toyota, which has staked its future endurance racing plans on the fuel, while Alpine's prototype suggests it, too, is considering changing from the current LMDh platform.

New UK-based 'Caddyshack'

The Andretti-Cadillac Formula 1 bid has taken a giant step forward with the opening of a new 48,000sq.ft facility at Silverstone in the UK.

Despite being rejected by Formula 1 for its initial entry, the team and Cadillac have pressed ahead with the opening of the new facility, saying, 'we have embarked on the next stage of our preparations to enter the FIA Formula 1 World Championship.'

More than 80 personnel have moved into the building from Andretti-Cadillac, which will house manufacturing facilities, electronics and model and machine shops. The new space will work with the main Andretti site in Indiana, USA and the Formula E facility in Banbury.

'While we are building an American works team, having a European base is a great way to attract the best in F1 talent, and install state-of-the-art machinery,' said the team in its statement.

With confirmation of its grand prix entry still hanging in the balance, the new facility has been designed to scale up quickly when required.

New IndyCar Aeroscreen arrives ahead of schedule

An updated version of IndyCar's Aeroscreen cockpit protection device was introduced ahead of schedule at the Grand Prix of Long Beach. The Aeroscreen 2.0, which is designed for road and street courses, was due to make its debut in May but was ready in time for an expedited roll out.

Weight saving without compromising strength has been a key task and around 5kg has been taken out of the device, which consists of a ballistic windscreen fitted into a titanium frame.

'We've taken that opportunity to also make the styling nicer, improve driver ventilation and make the thinner polycarbonate as strong as the thicker polycarbonate,' explains Tino Belli, director of aerodynamic development at IndyCar.

The weight-saving measures correspond to a 15.8kg reduction in car downforce, according to the series.

'We learned over the years where the limit of the vision was,' adds Belli. 'In the first version, we were conservative. We gave them a wider field of vision, but found out they didn't need it. So, now we've used that space to create a vent, which comes underneath the titanium top frame and is ducted down to blow air toward the driver's chest.'

IndyCar and Red Bull Advanced Technologies developed the first Aeroscreen ahead of its launch during the 2020 season.

Lola opts for ABT in Formula E

British company, Lola Cars, has linked with the ABT team to run its Yamaha entry in the FIA Formula E World Championship next season.

The collaboration between Lola and ABT is just one element of a joint venture between the two companies to explore far-reaching areas of sustainable motorsport. This will form part of Lola's strategy to re-establish itself as an industry leader, focusing on electrification, hydrogen and sustainable fuels and materials.

ABT is a long-time entrant into the Formula E series, winning the title in 2017 with Lucas di Grassi. The deal with Lola and Yamaha will see the end of its association with Spanish brand, Cupra, at the end of this season.

Lola confirmed at the end of March that it has partnered with Yamaha to develop a powertrain that will return it to professional motorsport for the first time since it went into administration in 2012. The former racecar chassis constructor was purchased by Till Bechtolsheimer in 2022 and has since been developing a new headquarters at Silverstone, UK with a view to re-establishing the company in racing and leading in sustainability.

'The focus of this project is squarely around technological development in which Lola is fully invested,' says Bechtolsheimer. 'We see the highly efficient 350kW electric powertrain that underpins the manufacturer's perimeter in Formula E as a cornerstone technology with exciting applications across many forms of top flight international motorsport in the coming years.'



In partnership with ABT and Yamaha, Lola is making a return to motorsport after over a decade away, intent on becoming a leading force in sustainable motorsport

Yamaha joins Formula E for the first time in the championship's 11th season, when the Gen3 cars will be updated with an Evo version.

'Yamaha Motor Company is accelerating the research and development of various technologies that contribute to sustainability,' says Heiji Maruyama, managing executive officer and director, Yamaha Motor Co Ltd. 'As the technical partner, we hope to acquire more advanced energy management technologies through the highest level of electric racing in Formula E. We also share Lola's new philosophy of sustainable motorsport and are very pleased and honoured to form this partnership with them.'

Meanwhile, Nissan became the first manufacturer to announce its commitment to the Gen4 Formula E regulations in March, agreeing to be involved until at least 2030.

'The technological breakthroughs that we make on the track will provide great insights to the development of our future products,' said Nissan Motor Corporation CEO, Makoto Uchida.



NXT Gen Cup dropped from Formula E support slot

Just days after confirming an expansion of its cooperation with battery producer, Clarios, the NXT Gen Touring Car Cup was abruptly taken off the Formula E support race schedule, ahead of the opening round in Misano, Italy.

The series confirmed in February it would join Formula E this season with its 100 per cent electric Minis featured in RE V34N4, but was struck off the bill shortly before the Italian race and will not return this year.

'NXT Gen's participation at the ABB FIA Formula E World Championship has been cancelled for Season 10 due to unexpected constraints faced by the support series,' said a spokesperson for Formula E.

The all-electric junior class was lined up to support Formula E at all four European rounds of the series with its Mini Cooper SE road car-based racers, engineered and built by the Swedish Lestrup Racing Team.



'Unexpected constraints' is the reason given for taking NXT Gen cup off European Formula E bill

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Position positive

How motorsport is perfectly placed on the roadmap for the future

Recently, motorsport engineers and technology leaders gathered at the MIA EEMS conference, when their wide experience made for a well-informed, stimulating discussion. Their interest and determination is to secure a sustainable future for the sport in a period of substantial change. All were acutely aware of the difficulties facing automotive transport and the need to find long-term solutions in which motorsport companies could play a role as a response to global warming.

Our business community is well aware of the threat this poses for our future, and the negative effect automotive transport is seen to be contributing to this position. It is clear that once this threat was identified to the wider public, demands for things to change justifiably followed.

Politicians have taken action and made decisions, which their political futures demanded, and called for fast action. Addressing global warming, which has taken millennia to reach this critical state, requires solutions that will need several decades to make a significant impact.

Positive steps *are* being made, but more are needed, and many agitate for more rapid progress. This impatience to resolve such a complex issue urgently has not proved particularly constructive. Consistent, careful, well-rounded progress, particularly in automotive, is essential to gain the support from vehicle users and the manufacturers who have to deliver these sustainable solutions.

The initial sales success of battery electric vehicles (BEV) has recently faltered. Whether this decline will be permanent, or is just part of a cycle of acceptance, is unclear, but the BEV solution needs to make rapid progress, not only in local car production, but in charging systems, which are currently being delivered too slowly. These delays have contributed to a potentially unwelcome economic position.

The unwelcome effect of the enormous commitment made by China to build up production of BEVs, batteries and inexpensive cars will soon be felt in the USA and Europe. This powerful position will have a knock-on

effect on employment and manufacture in these regions, where automotive has traditionally provided substantial employment.

The negative effect on global warming from the shipping requirements needed to bring these vehicles from China adds to the difficulties.

Is this turmoil a result of an unrealistic timetable set by politicians, or is it part of a reasonable cycle for this new challenge? If it's the latter, should there be more encouragement for investment in sustainable alternatives?



Motorsport can, and will, play a vital role in the worldwide journey to net zero

The ambition of net zero *will* eventually be reached and, with good direction, it could even meet the current target of 2050, but this will depend on clear, consistent leadership from governments.

It would seem industry believes this target is reachable, but in reasonable increments and with careful development.

Sustainable solutions

So what role could motorsport technology and engineering play to ensure these important targets are met? The MIA EEMS audience shared their knowledge of progress in several sustainable solutions that could help to achieve net zero.

Motorsport has always demonstrated progress when given complex challenges and there's no doubt this is one of those.

Long before public awareness of global warming, motorsport developed expertise and practice in the efficient use of energy. The reason is simple – wasted energy loses the race.

The UK's motorsport industry is ideally placed to act as a test bed and proving ground for sustainable transport solutions. It can also demonstrate these solutions to a public audience, preparing and enthusing them about the changes to come.

Currently, not only is our industry working hard to increase efficient battery power: It's also developing the use of hydrogen, sustainable fuels and hybrid powertrains. It will gather knowledge and experience from these solutions that, in turn, will help others make progress towards the net zero target.

Experience gained will facilitate and encourage steady and achievable progress on a wide range of fronts.

The success of the FIA Formula E World Championship demonstrates how valuable motorsport can be in popularising a net zero solution, making electric cars appear exciting and attractive. Motorsport also attracts investment and support from major technology-based brands who seek to influence a wide, relevant audience. These companies, and their investment in motorsport, will help the public regain an interest in the journey to net

zero and increase enthusiasm for vital changes.

The MIA's CTS24 Motorsport Technology Showcase on 17-18 October at Silverstone will focus on the opportunities for motorsport suppliers to meet these exciting challenges. This trade-only show is free to attend to all in our industry and offers the opportunity to network with influential figures, meet the 100+ exhibitors and engage in the many discussions that will take place.

The UK is in an outstanding position to grasp and lead this booming business opportunity. The reach of our industry now includes marine, aerospace and defence, as well as automotive, all of whom are on the same journey to net zero.

I welcome comments on this article and what actions *you* feel should be taken by our business leaders to benefit from these opportunities. Please email me at info@the-mia.com.

Chris Aylett is CEO of the MIA (Motorsport Industry Association) www.the-mia.com

Long before public awareness of global warming, motorsport developed expertise and practice in the efficient use of energy [because] wasted energy loses the race

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What once was...

A life in motorsport well lived, and well remembered

On 4 April 2024, my father, Michael, died, bringing to an end an extraordinary life. It's a life that has since been recognised through tributes and messages from around the world, and they have been a source of comfort for me and my family.

His love affair with racing started at an early age, drawing grand prix cars on his exercise book at school. It was with amusement that we walked the paddock at the Goodwood Revival looking at the Connaughts, him pointing out the ones that were the right colours, and those that were not...

Having grown up with family living near Crystal Palace in London, he was soon hooked on racing. He rallied with his great friend, John Quick, in an E-Type Jaguar, competing on the Coupe des Alpes and Tulip rallies in the mid-1960s.

Finding that same WOO II Jaguar again, now in the hands of collector, Nikolaus Ditting, drew him to Goodwood in 2022. He handed the original rally plates to Nikolaus, feeling they belonged with the car as part of its history.

Michael won the Tanganyika 1000 Rally in 1960 with Bill Fritschy, the East Africa Rally Champion, whom he met while doing his national service in Africa and described as 'a bit mad', but his real love and skill was writing.

He returned to the UK and landed a job on the *Croydon Advertiser* in London. The offices were just down the road from the workshop in which Eric Broadley was building the Lola GT. Serving as an apprentice there was a young Tony Southgate, who went on to design Le Mans cars for Jaguar, among many other great achievements.

In 1963, my father took himself to Le Mans to watch the Lola compete, and so started a relationship with that event that lasted until 2008.

Highs and lows

The years between saw him cover Formula 1, sportscar racing, the Targa Florio and even some Can-Am as editor of British publication *Motoring News*. The only time I ever saw him weep for a driver was on the 25th anniversary of Jim Clark's passing. He liked Jimmy immensely, and his loss to the sport at Hockenheim in 1968 was shocking to all. He covered racing through the 1970s, considered by many to be a golden age. Although the cars became iconic, the accidents haunted him. He loved the racing, the cars, the drivers, the lifestyle, but he hated the consequences of accidents. Reminiscing with my daughter recently, she was shocked at just how many fatalities he witnessed, and obituaries he wrote.

As racing became safer, he turned towards politics in the sport, and his criticisms of the likes of Jean-Marie Balestre, former president of the FIA, were, shall we say, lively.

Even years later, when asked to remember those days, the fire was still there. He could never quite trust Bernie Ecclestone and Max Mosley when they became involved in endurance racing, either. Although Stéphane Ratel regards Ecclestone as the best business partner he ever had, Michael never quite reached that plateau.

Love of GT racing

Michael had been friendly with the likes of Hill, Clark, Ickx and Bell, so it was perhaps surprising that he fell in love with the BPR series. It was one that could not really be described as professional initially, but it brought together a group of racers, stunning cars, a smattering of professional drivers, and the series and teams were run well. There was a friendliness to the paddock (though not on track!) and the series valued those who raced in it, and those who reported on it.

As racing transitioned to the mighty GT1 era, Michael took a small step backwards, trying to retire, although not very hard. His last Le Mans as a journalist saw Audi win.

He considered that to be the best Le Mans he had ever seen, and so stepped away, satisfied.

When GT3 was launched, he declared loudly that he wouldn't cross the room to watch these cars. Ironic perhaps then that his last race should have been the 24 Hours of Spa in 2022. By then, GT3 cars had become proper racing animals and he stood at Eau Rouge, watching the cars bottom out, before they headed up the hill. He never realised before how little the drivers could see in that compression, just the tips of the trees beyond the

corner, and little more. He asked, in a moment between cars passing, that some of his ashes be spread there. Not Le Mans? 'Nah, stinks of piss,' he replied.

In his office now is a wealth of cuttings, stories, unfinished manuscripts and a couple of knackered typewriters, beaten to death either by his writing, or his temper when they went wrong. My new prized possessions are an Olivetti 22, his first typewriter, and the red Olivetti Valentine he was using when I started attending races with him, before he transitioned to a new idea, a typewriter that used thermal paper. That paper was great in its light-proof envelope, but you had to 'phone through copy extra quickly when it was hot.

Some have told me his legacy will be his most recent books, *24:16* with Norbert Singer, and *Blue & Orange*, the story of Gulf in motorsport. However, I have his bound editions of *Motoring News* from when he was editor, from 1968 to 1976. They contain some brilliant reportage, delivered with the wit and humour that are the hallmarks of his writing, but also full of detail that take you back to the paddock, and the track. They are remarkable, as was he.

ANDREW COTTON Editor

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